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The Sixty-Sixth Meeting of the American Astronomical Society

By DEAN B. McLAUGHLIN

The American Astronomical Society held its sixty-sixth meeting at Yerkes Observatory, September 7-9, on invitation of Dr. Otto Struve, Director of the Observatory. This is the first time since 1922 that the Society has held a complete meeting there, though it will be recalled by many that in June, 1933, a brief visit to the Yerkes Observatory was a feature of the Chicago meeting. It should be mentioned in passing, that the Society had its beginnings in a conference of astronomers and astrophysicists at the Yerkes Observatory 44 years ago, and that the actual organization was completed at the same place two years later.

Driving up from Chicago Sunday afternoon, the writer saw a clear sky gradually cloud over, and by the time he reached Yerkes Observatory a hard rain had set in. The first scheduled event was a conference of teachers of astronomy, at which various topics were discussed, ranging from the threat of astrology and problems of publicity and popularization to the making of lantern slides. The writer arrived just as that session was breaking up.

Living accommodations for the visitors were provided by the George Williams College Camp on the shore of Lake Geneva directly below the observatory. Meals were served in the dining hall of the camp, to which the guests were summoned by a Chinese temple gong. From the camp to the observatory was about a six minute walk by the shortest route, but on account of the weather most of the members rode during the first two days, and apparently there were enough cars to transport them all. The astronomers had the camp practically to themselves, as the holiday season had come to an end.

The Council met in the observatory on Sunday evening and attended to the usual routine business, such as approval of the program and election of new members, as well as special matters to be noted later. They adjourned at eleven o'clock and returned to the camp, leaving plenty of business for another long session. Their second meeting was held Monday evening after the supper. Most of the time was taken up with the report of the Committee on Policy. Adjournment at 12:25 was most welcome to all concerned, but all business was finished and there was no need for another session. When they actually took stock of the results the President and Secretary asked each other what all that time was

spent on, but there is reason to believe that it will be long before another such session occurs. We hope so!

A space in the basement beneath the rising floor of the 40-inch dome was curtained off and furnished as a meeting room, and the whole group was easily seated there. The remaining parts of the circular room were devoted to exhibits of astronomical photographs.

The sessions of the Society as a whole began on Monday morning. First of all, tribute was paid to those taken from us by death during the past year:

Annie J. Cannon
F. Eugene Fowle
E. E. Free
Frank C. Jordan
Dayton C. Miller
Daniel W. Morehouse
Andrew Quintin
Charles Campbell Smith
De Lisle Stewart

The Society was then welcomed by Dr. Otto Struve for the Yerkes Observatory, and by Dr. Arthur Compton for the University of Chicago, and Dr. Joel Stebbins, President of the Society, responded. After a few routine announcements the program of papers was started.

There were four sessions for papers, Monday and Tuesday morning and afternoon. Altogether there were 47 titles on the program and 41 were presented either by the author or by a duly appointed proxy. No attempt will be made to summarize the papers. Those which were read by title were exclusively by absent authors or by some who had already presented one paper. The interval-timer which Stebbins brought to the meeting had good psychological effect, and many authors finished one or two minutes before the final bell. The "fortitude" of the presiding officer was also an important influence. With a little more practice, astronomers should be able to cut their presentation times in half, probably with benefit to both author and audience.

On Tuesday morning the annual business meeting preceded the session for papers. The election of officers was held, with the following results:

For Vice-President,	1941-43	Otto Struve
Secretary	1941-42	Dean B. McLaughlin
Treasurer	1941-42	Keivin Burns
Councilors	1941-44	S. B. Nicholson W. W. Morgan F. L. Whipple
Member of Division of Physical Sciences, National Research Council,	1942-45	Jan Schilt

A nominating committee to select the slate for next year's election was then chosen by ballot after nominations from the floor. The committee is constituted as follows:

Paul W. Merrill, *Chairman*
John C. Duncan
Peter van de Kamp.

The Treasurer presented his report, and it appeared that the main result of the increase of dues has been a larger number of delinquent members and only a slight increase of receipts. The Secretary reported the election of 19 new members by the Council, which brings the total membership to 645.

This is not the place to give a complete list of actions of the Council which were announced to the members, but some will be mentioned. The report of the Policy Committee indicates that the answers to questionnaires in general agree that present practice as regards conduct of meetings and Society affairs is satisfactory. But a number of very good suggestions were received, and these will be considered by the Council and the Program Committee.

Probably the most important actions of the Council were those concerned with publications. But since some of the arrangements still have to be made by the committee which is charged with this work, it seems best to omit details until an official announcement can be made.

The social activities were especially outstanding features of this meeting. On Monday evening the visitors were treated to a "chuck wagon supper" (illustrating the Texas influence) by Dr. and Mrs. Struve. The original intention had been to have the supper outdoors, but a heavy rain compelled a revision of plans, and it was served in the Mabel Cratty Building (the recreation hall) of the camp. The weather and the change of plans apparently did little or nothing to reduce the enjoyment of the occasion. After the supper there were various other activities. One group gathered about the piano and sang for probably a couple of hours. But the members of the Council missed all this, except for the muffled sounds which penetrated to the Council chamber.

A boat ride on Lake Geneva, which was scheduled for Monday afternoon was postponed until Tuesday, when a number of members enjoyed about an hour's excursion.

The Society dinner was held in the dining hall of the camp on Tuesday evening. Short after-dinner talks were given by Brouwer and Edmondson and, as a particularly pleasant surprise, by Mrs. Edwin B. Frost. Following these, Dr. Svein Rosseland gave an account of his journey with Mrs. Rosseland from Norway, across Siberia, and via Japan to the United States.

Professor Duncan then presented a resolution of thanks to our hosts for their hospitality, and to Jupiter Pluvius for inserting a little sunshine between rains. This marked the official conclusion of the meeting of the Society.

After the dinner the gathering repaired to the Mabel Cratty Building for dancing, bridge, and other amusements, and some formed an audience for Drs. Fath and Smiley who showed Kodachrome pictures of Mexico and Brazil, respectively.

A very large number of astronomers stayed on to attend the symposium on astronomical spectra which began on Wednesday morning

and continued through Friday afternoon. If the present number of POPULAR ASTRONOMY is a bit late, it is because the writer found it impossible to leave such an interesting program, and there was no time in which to prepare this report during the interval covered by the symposium.

As long as the official meeting of the Society lasted, it either rained or threatened rain, but Wednesday was beautifully clear, and the symposium was held on three cool and fair autumn-like days. On Wednesday evening the 40-inch telescope was available for viewing the cluster in Hercules.

This is not the place to give an account of the symposium. But it may be remarked that Dr. Paul W. Merrill introduced the term "symbiosis" into astrophysics, and a number of perplexed astronomers consulted dictionaries, which only partly cleared up the question. The best examples of symbiosis are such objects as Z Andromedae, in which a cool type of absorption spectrum is associated with a high-excitation emission spectrum.

Those who did not stay through most of the symposium missed an entertaining extra-curricular feature. On Friday, just after luncheon, eight or ten of the younger members presented the story of "Frederick, or an astronomer's adventure," with apologies to Munro Leaf and to Gilbert and Sullivan. The story was recounted in the best "Ferdinand" style and embellished with songs composed for the occasion: The astrologers' chorus, "When astrophysicists lambast our horoscopes," "I am the very model of a modern astrophysicist," "An Observer's life is such a happy one," "We've got a little list" (of celestial objects), and a Finale lifted from the "Pirates of Penzance." We hope that we have not seen or heard the last of "Frederick."

It is believed that this meeting establishes a record for attendance. The group photograph shows 171 faces, and one more can be seen projecting slightly from behind 135. Several who attended did not get in the picture. A precise census has not yet been taken, but it is estimated that 150 members and 30 guests were present. Another possible record, about five inches of rain in two days, was also established. As Dr. Struve pointed out, the 1922 Yerkes meeting was probably the hottest, and that of 1941 the wettest. Next time he promises another sort of distinction but has not committed himself as to details.

It is one of the good features of these meetings that we forget, for a time, the affairs of the outside world. So far as many of us were concerned, the war stopped from September 8-12. But now we are again face to face with reality, especially the Secretary, who can look forward to a program of work which will just be clearing up when the arrangements for the Christmas meeting in Cleveland will require his attention.

ANN ARBOR, MICHIGAN, SEPTEMBER 16, 1941.

An Astronomer's Trip to South America

By ALICE H. FARNSWORTH

All my life I have wanted to sail south, to see the hidden glories of the southern skies and the changing aspects of the celestial sphere. A sabbatical leave which brings to reality even one lifelong desire is a noteworthy event, attesting the importance of this educational custom. When the abbreviated passenger list of a freighter comprises a group with common interests the voyage takes on ideal aspects, as it did when two eclipse expeditions found themselves aboard the Mormacgull sailing from New York for South America on August 24, 1940.

I was fortunate to be able to carry with me research equipment designed for use throughout the trip, but adaptable for eclipse purposes also. McDonald Observatory provided a rapid spectrograph capable of recording in as brief a time as ninety minutes the more conspicuous radiations emitted by the atoms of the terrestrial atmosphere during the hours when sunlight is withdrawn. The spectrograph weighed about thirty pounds and went along as hand-luggage. The portability of the instrument and the fact that it required neither feeding telescope nor driving-clock were important aids to studying the intrinsic light of the night sky in as many different locations as possible. Indeed so truly did the plan of work with this adaptable instrument act as an open sesame wherever I went that I wonder whether I shall ever again be satisfied to travel to distant parts without the ingratiating companionship of a portable astronomical instrument!

On Saturday, one week after the date of sailing, we overtook and passed the Sun. At noon, our latitude being 9°.5 north and its declination $+8°.5$, all repaired to the upper bridge and indulged heavily in picture-making to show the absence of shadows. That evening found everybody again on the upper bridge watching the sunset, which was a glorious affair with crepuscular rays visible in both west and east. Bright stars were identified as they appeared one after another in the rapidly diminishing twilight. The brilliant pair in Centaurus were far enough above the horizon to make us eagerly follow their pointing to get a glimpse of the Southern Cross before it should set. But the clouds were heavy there and only β Crucis was glimpsed. (See Fig. 1.) Meanwhile the Zodiacal Light was easily visible. Sagittarius and Scorpio with their star-filled depths were very conspicuous, looming in new heights. The Big Dipper was plunging into the ocean as Polaris made its last appearance, and it was time to be learning pointers to the dimly-marked South Celestial Pole.

By this time I had decided that the ocean was not the place to expect "photometric" nights of uniform clearness, and that observations would have interest and a certain value, even if interrupted by clouds. Captain Vomberg, cordial to the idea of my setting up the spectrograph on the upper bridge where darkness was assured, roped off a corner on the port side where the instrument could be securely strapped. The chart-house provided convenient shelter for it during the day. For three nights in succession the heavens were my kingdom, a steamer-chair my throne. Now and then a film must be changed, a shutter closed, or a canvas cover hastily installed during a spill of rain quickly over, but most of the hours could be spent delightedly trying to absorb the new skies. I

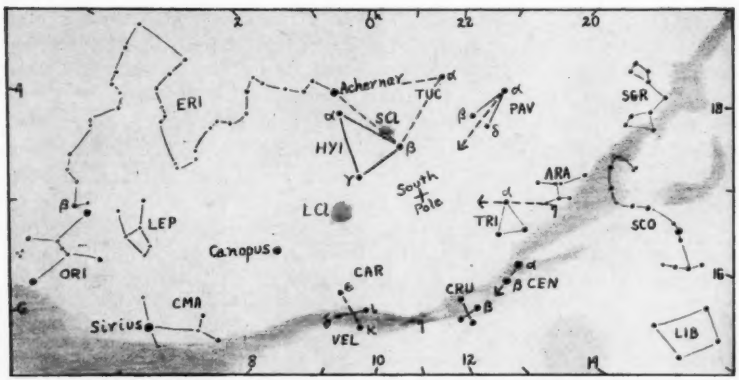

FIGURE 1

Map of the southern sky, illustrating references in the text, otherwise incomplete. Full lines connect stars within a constellation. Dash lines are guiding lines. The False Cross is composed of stars in both Carina and Vela.

resolved to advise my students in future to learn thoroughly a chain of stars defining the position of the celestial equator, as an aid to orientation in new latitudes. On the first night especially, clouds were rather constantly coming and going, some of them soft, immaterial, but very black and moving fast. As they floated in layers across the Galaxy, they produced chiaroscuro effects, helpful in the interpretation of photographs where diffuse nebulosities, dark and bright, overlie one another.

Sunday night we were close to the equator. The "Y" of Aquarius seen upright in the east appeared later in the night exactly upside down in the west. Orion rose comfortably reclining on his side and remained so as he approached the zenith. Lepus, no longer crouching between Orion and the horizon, kept pace vertically, south of the hunter's feet. The entire splendid sweep of Eridanus from β, close to the foot of Orion, to Achernar, the "last of the river," was visible before I went to bed. The position of the Lesser Magellanic Cloud was determined by

locating the triangle Achernar-α Tucanae-β Hydri. The third star was actually below the Cloud which was not seen until the following evening.

Eight degrees south of the equator, on the easternmost tip of Brazil, lies Recife, capital of the state of Pernambuco. We arrived here late on the tenth day out of New York and cruised up and down outside the port all night. The continued opportunity to study the sky was rewarding. From heavy gray cloud-banks emerged first the Pointers, then bit by bit the Southern Cross, visible to us in its entirety for the first time. In the memorable picture were included the sky-glow from the lights of Recife twenty-five miles away, and to the west the Zodiacal Light, very bright, almost vertical, extending well up into Libra. α Centauri lay in its dark rift in the Galaxy and the Coalsack near Crux looked like a small dark cloud that would not move on. Far to northward close to the horizon was η Ursae Majoris, last vestige of the Bear's tail. Still farther north we detected one of the North Pole's Guardians, the coils of Draco higher up helping us to be sure. That the South Pole was already visible was evidenced only by the convergence of adopted lines of direction from Pavo and Ara.

Our indebtedness to Mr. Linthicum, United States Vice-consul at Recife, to Dr. Henderlite, American missionary under the Presbyterian Board, and to Dr. Marinho in charge of the engineering project of the Brazilian government at Curema, state of Paraiba, our headquarters for the solar eclipse of October 1, has already been mentioned in Dr. Smiley's account of the eclipse expedition in the April number of this magazine. The kindness received at the hands of these persons, their families, their neighbors, and their associates cannot be exaggerated and will never be forgotten. Without it, expressed in many practical ways, a three-weeks Brazilian sojourn 250 miles inland on short notice would scarcely have been practicable; with it the experience is recalled as a delightful one of amazing interest, marred only by conspicuous non-coöperation on the part of Jupiter Pluvius.

Spectrographic work on the night sky was considerably hindered at Curema by the smoke which frequently rolled over from the power plant, and by the bright lights kept burning all night to accommodate the urgent work on drought-control. The first of four films exposed gave evidence that the ride inland over roads with rough stretches had disturbed the focus of the collimator. A microammeter was also put out of commission. Fortunately after the eclipse I was able to borrow an even better microammeter from a member of the National Geographic Society party. All films were developed at night in the ice-compartment of the refrigerator which was one of the luxuries provided in the IFOCS guest-house.

For the eclipse a small lens supported by four rods served to focus the Sun's image on the slit which was somewhat reduced in width. The spectrograph was attached to the mount carrying the Brown University-

Skyscrapers cameras.* It was hoped that, from a single exposure of about four minutes, evidence might be secured regarding the variation of the chief coronal radiations with distance from the limb. As it turned

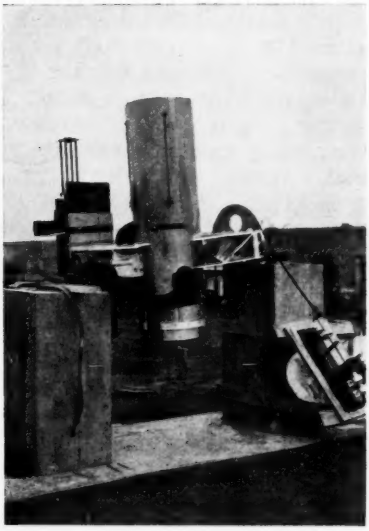

FIGURE 2

ECLIPSE INSTRUMENTS MOUNTED AT CUREMA, BRAZIL

At the left the spectrograph; Schwarzschild camera central, with Schmidt in front. Note low elevation of polar axis, 7° above southern horizon.

out, the only source of illumination during totality was clouds. The eclipse spectrogram shows considerable fog and a few hazy streaks whose identification as spectrum lines or bands is open to some question.

Before going inland from Recife, an afternoon was spent in the little town of Olinda, old and very interesting, on the coast about ten miles to the north. Here on the palm-girt beach presided over by a black-and-white-striped lighthouse, we watched a jangada, or fishing-raft, being hauled up over the sand and reflected that, as a plane flies, Africa was just over yonder. The tiny cylindrical observatory was being freshly tinted blue, in preparation for eclipse visitors destined here to be suc-

*C. H. Smiley, The Brown University-Skyscrapers Eclipse Expedition to Brazil, POPULAR ASTRONOMY, **49**, 189, 1941.

cessful. Not far away on a small pillar a tablet read thus:

PASSAGEM DE VENUS
PELO DISCO SOLAR
EM 5-6 DE DEZEMBRO 1882
COMMISSAO BRASILEIRA

Time is precious when traveling with a spectrograph known to prefer moonless nights. It seemed important to reach my ultimate destination, the National Observatory at Cordoba, by the time the October moon was well out of the way. For this reason I was glad to catch, on the second day after the eclipse, a Brazilian boat leaving Recife for Rio de Janeiro, a thousand miles to the south. On the Itaimbé I was interested to meet two eclipse-seekers returning to Buenos Aires, Mr. Völsch and Dr. Mettler, and to see Tuesday's corona in some photographs which Mr. Völsch had made at Patos, thirty miles east of our station.

Nine days in Rio were too short to see and do everything desired. They were however quite long enough to enlist me in the ranks of enthusiastic admirers of this beautiful city. No hurried description can do it justice. Vividly recalled is an evening spent at Icarahy Beach. As I tramped the smooth wet sands which were mirroring green waves, I watched first a superb sunset, then the fascinating spectacle of Rio's lights across the bay gradually coming on. Returning on the crowded ferry, I labored hard and vainly to turn Mercury into Spica. The following afternoon I sought out Rua General Bruce for the National Observatory in its fine location overlooking the harbor. Numerous domes, glimpsed high up among stately royal palms, made me realize from the sidewalk below that the formidable-looking elevator at hand must indeed be the accepted method of approach. A chance passer-by helped me to push the right buttons. Arrived at the proper level I soon found hospitable members of the staff with whom the afternoon was most pleasantly passed. It is only fair to my hosts to say that more of the conversation was carried on in English than in Portuguese. In the administration building, impressive with its marble pillars and rotunda, I recall especially Urania in bright blue stained glass, a delightfully artistic lecture-room, and a fine library with superb views from all the windows. Through these swept the breezes of heaven, as attested by a remarkable aggregation of translucent green paper-weights anchoring the current periodicals and publications on the big central table. Under the guidance of Sra. de Faria, Dr. Costa, and Dr. Lemos, I inspected the instruments in numerous domes, noting especially the excellent equipment for time-service. Work on tides and the variation of latitude also receive emphasis in this observatory. A photograph of the eclipse two weeks earlier, well seen in Rio, was of current interest.

Three and a half days on the *Brazil* accomplished another thousand miles and brought me to Montevideo, in my second South American country, on Monday morning, October 21. On the night's run across

the great "River Plate" to Buenos Aires, I first saw the Magellanic Clouds really well. A spectrograph does not enter Argentina quite as expeditiously as an astronomer and I greatly appreciated the help of another astronomer, Dr. B. H. Dawson of La Plata, and of representa-

FIGURE 3

Above: View of Rio de Janeiro from the National Observatory.

Below: Members of the Staff at the Observatory in Rio. At the left, Sra. de Faria and Dr. A. Lemos; at extreme right, Dr. D. Costa.

tives of the consular service who were on hand at the dock in Buenos Aires. Here again, as earlier on the sidewalks of Varick St., in New York, a mark was placed inside the box as guarantee of its identity on departure from the country.

With the moon at last quarter and day-trains to Cordoba running but

twice a week, three days only were allotted to getting acquainted with the great modern metropolis, Buenos Aires, and its young neighbor La Plata, thirty miles to the south. Making headquarters with the Dawson family meant introduction to the pleasant surroundings of a home in Spanish style and to a group of busy young people receiving their education in the local schools and university. For the great attractiveness of the Observatorio Astronómico de la Universidad Nacional at La Plata I was unprepared. In beauty of grounds and planting and general charm it heads the list of those I saw. Of course I visited it in

FIGURE 4

Administration Building at the Observatory of the National University at La Plata. Dome of the 31-inch reflector at the right.

late October which is early spring. Perhaps that accounts for greater susceptibility to bird-songs, apple-blossoms, and a great bed of nasturtiums near the Director's residence than to dimensions of telescopes and details of research problems. Anyway I heard here the chingolo, as well-beloved as the chickadee, and the persistent biente-veo tyrant, and noted the north-facing nest of the horneros who had built in a niche of the big dome. Remembered with pleasure are the wrought-iron screens before the windows in the dome of the 17-inch telescope. This telescope with its unusual ratio 22/1 was mentioned as possibly the longest without a rising floor. Director Aguilar is concerned at present with the measurement of a long terrestrial arc in Argentina.

The twelve-hour journey on the Central Argentine Railway from Buenos Aires to Cordoba takes one not only 450 miles inland, but also 1,440 feet up. This old city, once the center of Jesuit activity and dotted with churches, and site of the second oldest University on the continent, lies in the edge of the Cordoba hills much frequented by holiday-seekers.

The Observatorio Nacional Argentino, founded in 1870, is situated on the barranca overlooking the city from the south.

It became evident that the fine display of city lights visible from the roof of the Observatory, certain near-by street lights, and a capricious column of smoke from a too-close municipal utility to the west conspired

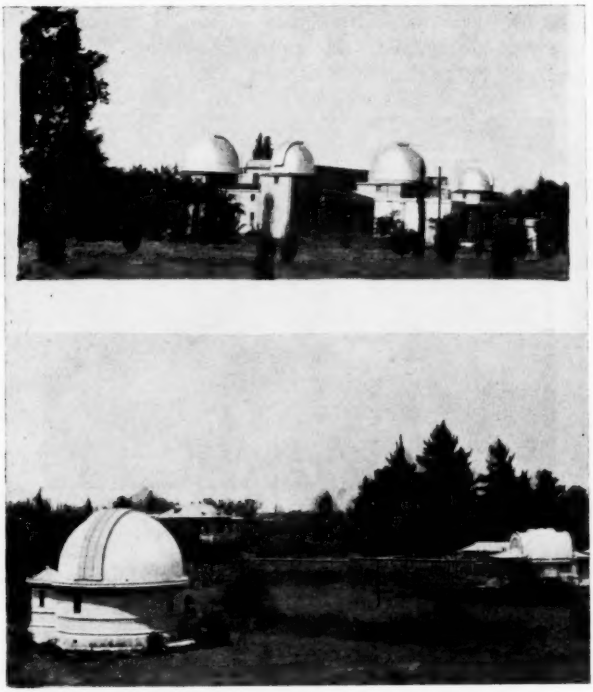

FIGURE 5

Above: The National Observatory at Cordoba, Argentina. View from the Southwest.

Below: Dome and Transit-house at the Observatory of the University of Chile at Santiago.

against studying to good advantage the intrinsic radiations of Cordoba's beautiful, transparent sky. Its daytime blue is something to remember. Fortunately another resource was at hand. About fifty kilometers to the southwest in the Sierras Chicas at an altitude of approximately 4000 feet is Bosque Alegre, the Observatory's mountain station. Aside from trees that have been laboriously planted, the "bosque" or "woods" are all down in the valley at the estancia, visible from the mountain, whose owner donated the site for the Observatory, and for which the latter was

named. Here have stood for a number of years an impressive dome housing the mounting for a sixty-inch reflecting telescope, a smaller dome part-way down from the top, and an observer's cottage, all built of attractive gray stone; also a caretaker's house, a transit-house at present used as a school, and the teacher's residence. The location is charming, with fine views in all directions: westward, by day, the furrowed slopes of the Gigantes, terminating a great plateau in the Sierras Grandes, often stand out clearly as does Champaqui, highest of the

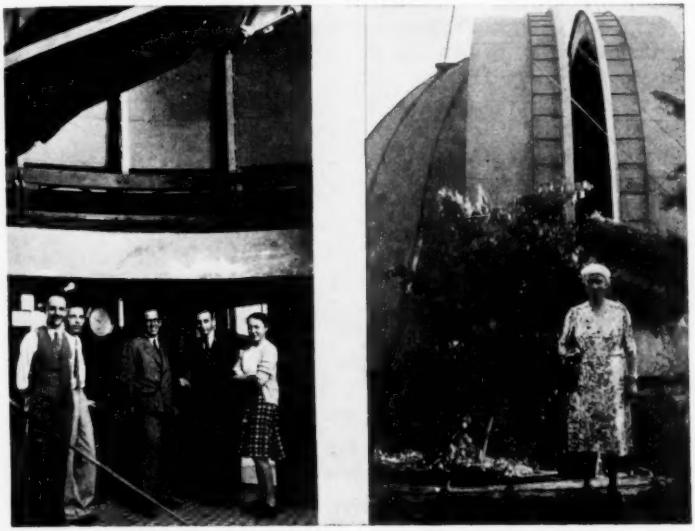

FIGURE 6

Left: Members of the Staff at Cordoba in the dome of the astrographic telescope on the day of Mercury's transit. From the left: Mr. Dartayet, Mr. Platzek, Mr. Bobone, Director Gaviola, Miss Miriam Gaviola.

Right: Dome of the 37-inch Reflector at the Observatory of the Catholic University in Santiago. Former southern station of the Lick Observatory. Writer in foreground.

Comechingones; in the plains to eastward, at night the lights of Alta Gracia shine like precious stones set in a tiara, while those of more distant Cordoba stretch in serpentine fashion along the horizon. A bus goes by on the main road twice a week leaving mail and supplies and the Observatory truck arrives at less frequent intervals. Twice a week, on Sunday and Thursday afternoons, the gates are opened to admit visitors to the reservation. During the school year which ends about the first of December, approximately thirty children come on foot or horseback from homes in the surrounding hill-country. They are given a hot noon-meal in a building just behind the cottage.

This splendid isolation, and the absence of artificial lights made the spot excellent for my purposes. I was fortunate in arriving before any other observing program was under way on the mountain, so that I had the truly sumptuous provision of the big dome to myself without competition. The spectrograph rested on a shelf at the base of the slit, revolving with the dome. Free access to the sky from horizon to zenith at any azimuth was thus afforded without exposure to the elements (and high winds do sweep this mountain). Dark-room facilities were of course at hand; also a comet-seeker by means of which I could keep track of sun spots and explore handily, from a big southwest window, various regions in the new sky.

FIGURE 7

BOSQUE ALEGRE, MOUNTAIN STATION OF THE NATIONAL OBSERVATORY AT CORDOBA

Transit-house to right; in center, entrance to tunnel leading to clock-room.

For exactly two months, from October 31 to December 31, this richness was mine. Two trips to Cordoba during the period of full moon precluded any symptoms of monotony and gave opportunity to use the library. The first trip coincided neatly with the transit of Mercury. While an interested group of visitors in the lower corridor were watching the entrance and progress of the planet on a large projected image of the sun, Mr. Bobone and Mr. Platzek secured very satisfactory photographs of the planet just after ingress, using the thinly-silvered lens of the astrographic telescope. The telescope with which the Cordoba Durchmusterung was made, its lens similarly treated, afforded an excellent direct view of Mercury on the sun. Clouds hindered to some extent before the sun set. The December journey down the mountain brought excursions to La Cumbre in the Cordoba hills and to Mina

Clavero in the Sierras Grandes where summer vacationers were already beginning to be numerous.

Any night which included as much as two hours of dark sky (*i.e.*, moonless and beyond or before twilight) was considered available. I was able to make exposures, during a part or the whole of the dark interval, on 21 out of 44 available nights. The time used on a single night ranged from half an hour on December 28, when I went up to the top at 4:00 A.M., to get some dawn exposures, to eight and a quarter hours on December 31 when twilight, darkness, and dawn of a summer night were all photographed. (This longest possible interval was increased to more than nine hours, three weeks later at Potrerillos, five degrees nearer the equator.) One does not need to compute the number of misfortunes, preventable and otherwise, that can occur during observing by this or that technique, because given time enough they will all occur and their number can be arrived at empirically! There was that last night on the mountain, when program and weather indicated a rare, complete twilight-night-dawn series. The observing-book tells the story: "At 2:45 I made the bitter discovery that the inner shutter had remained closed since 21:59" and continues, paraphrasing Horace Mann: "Lost: five golden hours, each set with sixty diamond minutes. No reward offered, for they are gone forever." And there was that hot afternoon in Cordoba after three successive all-night runs, when I carried ice from Mrs. Zimmer's refrigerator to the Observatory to get the developer down to 70°, and found not *one*, but *three* of the previous night's films so badly off center as to be probably useless. It was the entire product of my last beautiful night of observing in Cordoba when even the smoke-stack was quenched because it was New Year's Day. This time the observing book says only! ! !.

Granted that late spring and summer are not the most favorable season for clear skies at Bosque Alegre, and quite apart from the value of the films secured, never shall I lose the memory of those marvelous nights under the southern heavens. From the coming of the rosy fringe of twilight arch in the east to its reappearance in the west at dawn, those nights were full of wonder: Zodiacal Light and Milky Way like a great pair of wings springing from the western horizon; that most exciting part of the Galaxy running past Triangulum, through Pointers and Cross, narrowing to approach the brilliant region of η Carinae, then on past the False Cross; the Southern Cross that barely grazed the horizon in the evening gradually changing angle through the night until it was almost erect as it faded into dawn; the ever-recurring novelty of finding Sirius and Canopus, not flashing low on the horizon but flanking the zenith, one on each side; and the persistent fascination of the cosmic clouds in the south, the black dust-cloud that is the Coalsack always dogging the Southern Cross and the bright, near galaxies which we call the Magellanic Clouds. Great banks of terrestrial clouds near the horizon frequently furnished spectacular displays of lighting, with no audible

thunder. It was an odd experience to go home one night through thick fog lit by constant flickering flashes.

None of this would have been possible without the cordial and generous co-operation of Director Henrique Gaviola and his staff. I wish to record here my deep gratitude to them. Dr. Gaviola welcomes visiting astronomers and hopes that more will come, with the installation of the 60-inch telescope at Bosque Alegre. The mirror had been taken up the mountain and the observing platform was practically finished when I left in January. To Dr. and Mrs. Zimmer, for their hospitality and constant attention to my welfare, I am especially indebted. Dr. Zimmer's Second Fundamental Catalogue is near completion. Cordoba's loss in Dr. Zimmer's retirement is our gain, as with his wife he expects to spend some time in this country.

My last glimpse of the silvery dome at Bosque Alegre was from above, crossing from Cordoba to Santiago de Chile by Panagra plane on Sunday afternoon, January 5. Here is an occasion where experience and ordinary words on a flat page remain hopelessly incommensurable. On the journey of 480 miles covered in three and a half hours, one longed to hold back especially those minutes, fifty of them, when we were actually over the Andes themselves. After rising to 19,000 feet, there beneath us all too soon was the great city of Santiago, lying between the mountains we had crossed and the lower coastal ranges.

At an appreciable distance from the center of the city is located the Observatorio Astronomico Nacional de la Universidad de Chile. Mr. Federico Rutllant, in charge of the meridian circle, introduced us to telescope after telescope over a campus of considerable extent. Here was the third astrographic instrument I had seen in South America; apparently work on reductions of plates made thirty years ago is still in progress. This observatory provides the time-service for its long narrow country and publishes an *Annuario Astronomico,* a copy of which received thus at the change of the year proved exceedingly useful on the return trip. Less easy to invade was the Manuel Foster Observatorio de la Universidad Católica on Cerro San Cristobal. An evidently well-instructed little girl in a pink dress held the keys to the gate. Even the persuasive Spanish of the Mount Holyoke alumna who was my guide that afternoon and who could recall incidents of the days when the expedition from Lick Observatory had occupied the big dome up yonder, had little effect. Eventually Dr. Erich Heilmaier came to our rescue and we saw the telescope famed in the annals of radial-velocity determination. It was good to hear that, after a long period of inactivity, the mirror had within the month been re-silvered. The library in the small adjacent building was being put in order by Dr. Heilmaier.

The minor tragedies encountered during the last days of observing in Argentina made me very desirous of having one more try at the night sky of South America from its west coast. Thus it was with delight that a telegram replacing a lost letter was received in Valparaiso the

day before sailing. Plans were quickly made to leave the *Santa Elena* (Grace Line) at Barquito, a day's journey northward, port for the Andes Copper Mining Company at Potrerillos, nine thousand feet high. Taken in charge even before landing by the hospitable Morris family (Mrs. Morris is a sister of Mrs. Helen Porter Jose), I spent a memorable fortnight in this community of fifty or so North American and several thousand Chilean families. The sun shone every day and the spectrograph was at work on nine of the ten available nights. There is said to be a fly in every ointment, however, and in this case it consisted of the smelter's smoke, incalculable in elevation and direction on a given

FIGURE 8

MINING COUNTRY AT POTRERILLOS, CHILE

Near plant of Andes Copper Mining Co. At lower level: cars loaded with ore at entrance to tunnel; above, auto road.

night, and the very thorough lighting of the residential section, combined with solicitous vigilance of night-watchmen. By the judicious removal of a fuse here and loosening of a bulb there, and by moving about from garden-fence to chicken-coop to a neighbor's west-facing veranda, some rewarding experiments were made. A real photographic dark-room was available in a neighbor's basement. The serious nature of my mission was some measure of protection in this extremely sociable community. Time in the daytime for sleep and for developing films had to be reserved. Harbinger of home was the sight of the entire Big Dipper over the northern mountains at 4:00 A.M.; only the paws of the Bear, sprawling upward, had been visible from Cordoba.

Inexorably the *Santa Clara* and the day of departure approached. Saturday, January 25, after a night of work and an hour of sleep between six and seven o'clock in the morning, I boarded the company car for the trip to sea-level, this time in daylight: at first descending rapidly and winding through eleven tunnels, from the face of one moun-

tain to another; then dropping slowly and steadily for the last four thousand feet in altitude, down the broad valley of an old salt river, flanked by the barren yet amazingly colorful mountains.

The first night on board meant to me a whole night for sleep. Yet how I regretted it when word got about on Sunday that a bright comet had been seen by the ship's officers on the bridge early that morning! Could this be Cunningham's Comet, located with some difficulty in an opera-glass, on two mornings in the smoke and dawn at Potrerillos? Monday morning, though marred by clouds, brought a thrilling view of a "real comet," surely the finest visual object since Halley's. That day we lay for several hours off Mollendo, port for Arequipa which was too far away to visit. I did not go ashore and was all the more incredulous, and keenly disappointed when I learned later that Sr. Fernando de Romaña had come aboard and searched for me in vain. Sr. Romaña, it will be recalled, photographed the solar corona* at the 1937 eclipse in Peru. He had kindly offered the use of his equipment for my South American venture.

Full details of the sixteen days on the Grace liner do not belong to an astronomical chronicle. The comet changed over into the evening sky where it vied in interest with movies on deck against receding southern stars as backdrop. Clouds prevented finding the comet after February 6; not until I reached Massachusetts did I learn of its multiple discovery in the outside world. Stops were made at ten ports in as many days; then straightaway from Barranquilla, Colombia (leaving Wednesday evening, February 5), to New York. Friday morning I rose early for a last view of the Southern Cross; Saturday a delicious freshness in the air replaced the previous muggy heat; Sunday "Br-rr," warm clothes out, a gray day and a gray sea; Monday happy landing.

JOHN PAYSON WILLISTON OBSERVATORY, MOUNT HOLYOKE COLLEGE,
SOUTH HADLEY, MASS., JUNE 24, 1941.

The Telescope, Vol. IV, 83, 1937.

Color Temperatures of Gamma Cassiopeiae

By RALPH B. BALDWIN

For several years, since the early work of Chalonge, Safir,[1] Greaves,[2] and others,[2] γ Cassiopeiae has been known to be not only a spectrum variable and light variable, but a temperature variable as well.

Numerous color temperatures have been published from observatories in Europe and America. Unfortunately, the different observers base their measured gradients on various zero points. It now seems well established that the color temperatures measured by Robley C. Williams[3] of the Observatory of the University of Michigan for several A0 stars are accurate enough to determine the zero point of the color temperature scale. Hence the author in a previous paper[4] converted all published color temperatures to the Ann Arbor scale. These temperatures then outline a rather smooth curve, shown in Figure 1B. The conversion was accomplished by use of data given by Williams correlating the temperature scales found by the various observers.

Intensity measures of the spectrum of γ Cassiopeiae by all observers have shown that prior to 1939, at least, the energy distribution was very similar to that of a black body of varying temperature in the range of $\lambda\lambda$ 6500 to 4000. The temperatures are all between 16200° K and 7300° K. All published temperatures and gradients known to the author are given in Table 1.

Since 1934 most of the spectrograms of γ Cassiopeiae taken at the Observatory of the University of Michigan have been on Process emulsion. All of these plates had spot standardization. An attempt is made here to use these plates statistically to measure changes in the relative energies at two wave-lengths and to correlate these changes with the observed temperature determinations, thus filling in gaps in the latter series and extending it.

Two wave-lengths, $\lambda\lambda$ 3900 and 4450 were selected as both were free from absorption and emission lines, were well separated in wave-length, and at each point the exposure was such that the measured densities lay on the straight line portion of the characteristic curve.

The blackening of the photographic plate due to the stellar energy at λ 3900 is the result of several factors. It was measured photoelectrically on an unusual photometer designed by Mr. Richard F. Kinnaird and in use at the Dearborn Observatory. The density measures were reduced to relative energies in the following manner.

$$J_{3900} = Jo_{3900} \times A_{3900} \times T_{3900} \times S_{3900} \times P_{3900} \times C_{3900} \qquad (1)$$

where J_{3900} is the energy at λ 3900 recorded by the photographic plate. Jo_{3900} is the original stellar energy at that wave-length just outside the

earth's atmosphere. A_{3900} is the transmission factor of the atmosphere, T_{3900} and S_{3900} are the percentages of light of λ 3900 transmitted by the telescope and spectroscope respectively. P_{3900} is the sensitivity of the

TABLE 1

OBSERVED AND REDUCED COLOR TEMPERATURES OF γ CASSIOPEIAE

Date	J.D. 242+	Publ. C.T.	C.T. A.A. Scale	Observer
1926.78		16100° K	13150° K	Greenwich
1935.71	8061	14000	12150	Chalonge, Safir
1935.71	8061	12500	11000	" "
1936.87	8486	9700	8700	Greenwich
1936.87	8488	10000	8700	Chalonge, Safir
1936.89	8493	10500	9350	Greenwich
1936.92	8504	10200	9100	"
1936.93	8507	11800	10300	"
1937.33	8656	8100	7400	Vanderkherkove
1937.48	8709	8050	7300	"
1937.51	8720	8800	8100	"
1937.59	8748	12000	10600	"
1937.67	8777	8400	7600	"
1937.67	8778	9650	8600	Greenwich
1937.68	8782	9300	8350	"
1937.68	8782	9400	8450	"
1937.68	8783	7950	7950	Williams
1937.68	8783	10500	9300	Vanderkherkove
1937.73	8800	8950	8100	Greenwich
1937.74	8806	10400	9200	Vanderkherkove
1937.74	8806	8950	8200	"
1937.76	8811	8800	8000	Greenwich
1937.76	8811	9150	8250	"
1937.79	8823	15200	12800	Vanderkherkove
1937.83	8837	8000	8000	Williams
1938.21	8975	12150	10600	Greenwich
1938.24	8986	12150	10600	"
1938.27	8998	12750	10900	"
1938.53	9094	12150	12150	Williams
1938.53	9094	11500	11500	"
1938.55	9100	13650	11600	Greenwich
1938.57	9107	13000	11100	"
1938.67	9144	13300	11400	"
1938.71	9158	12900	11000	"
1938.71	9158	14750	12300	"
1940.54	9825	16200	16200	Williams

NOTES

Column 3 contains the published color temperature. In some cases this is derived from the published gradient. Column 4 contains the color temperatures after reduction to the Ann Arbor scale of R. C. Williams. The first temperature is a mean of eleven points. The others are individual points. In Figure 1B, the temperatures by Vanderkherkove have been combined into two mean points because of their relatively large scatter. They are 8350° K and 8575° K at J.D. 2428708 and 2428793, respectively.

Process plate, and C_{3900} is a factor included because the effective wavelength of the standard spots is not λ 3900, but is much farther to the red.

There is a similar array for λ 4450 and the ratio may thus be taken.

$$\frac{J_{3900}}{J_{4450}} = \frac{Jo_{3900}}{Jo_{4450}} \times \frac{A_{3900}}{A_{4450}} \times \frac{T_{3900}}{T_{4450}} \times \frac{S_{3900}}{S_{4450}} \times \frac{P_{3900}}{P_{4450}} \times \frac{C_{3900}}{C_{4450}} \qquad (2)$$

On each plate the effect of the atmosphere on the energy ratio may be eliminated approximately by computing the zenith distance of the star when the plate was taken, and by using a *mean* atmospheric transmission curve determined for Ann Arbor by R. C. Williams.[5] For an individual plate the corrected energy ratio could hardly be trusted because of local deviations from the mean atmospheric transmission, but statistically, with many plates, the method is valid. Only the differential atmospheric effect is important here.

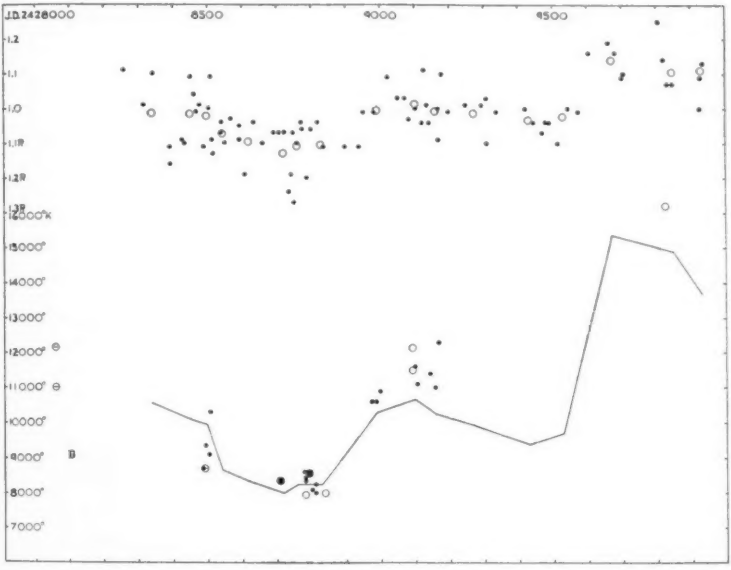

FIGURE 1

In the upper part are shown variations in measured energy ratios, E_{3900}/E_{4450}, with time, in the spectrum of γ Cassiopeiae. Filled circles are individual measured points; open circles are five point means.

B. Comparison of temperature curve derived in this paper with published color temperatures. The latter have all been reduced to the scale of R. C. Williams. Θ Chalonge and Safir. · Greenwich observers. ○ R. C. Williams. • Vanderkherkove.

The factor:

$$\frac{T_{3900}}{T_{4450}} \times \frac{S_{3900}}{S_{4450}} \times \frac{P_{3900}}{P_{4450}} \times \frac{C_{3900}}{C_{4450}}$$

is a constant within the errors of the method. The relative reflecting

power of aluminum at λλ 3900 and 4450 remains essentially the same even though the absolute reflectivity varies with the age of the mirror coating. The last term is practically constant as only the straight line portions of the characteristic curves from the standard spots were used and the relative slopes of the characteristic curves for λλ 3900 and 4450 are always similar.

Consequently, once the effect of the air is eliminated from the ratios of energies we have

$$\frac{J_{3900}}{J_{4450}} = \frac{Jo_{3900}}{Jo_{4450}} \times K \qquad (3)$$

where K is a constant.

The upper part of Figure 1 shows the ratios measured on individual plates by this method. The open circles represent five point mean values. A definite variation is indicated. Table 3 gives the Julian Day of each plate, the measured energy ratio, the temperature corresponding to each measured ratio, the five point mean ratios, and the five point mean temperatures derived from the average temperatures of individual points. If the letter "R" is appended to the ratio, the continuous spectrum at λ 4450 is stronger than that of λ 3900 in that ratio. If no letter follows the ratio, the violet color is stronger.

Table 2 correlates the actual energy ratios for temperatures from 6000°K to 25000°K in the sense E_{3900} divided by E_{4450}, computed from the black body formula.

The spectrophotometrically observed temperature of γ Cassiopeiae at J.D. 2428800 is about 8300°K. For this temperature we may take the corresponding ratio of energies for λ 3900 and λ 4450 from Table 2. A comparison of this value, 1.110, and that found for the same date from the measured ratios from the mean curve of the upper part of Figure 1, 1.092R, leads to a determination of the constant of equation (3), K = 0.825.

TABLE 2

RELATIVE ENERGIES

Temperature	$\frac{Jo_{3900}}{Jo_{4450}}$	$\frac{Jo_{3900}}{Jo_{4450}} \times K$
6000° K	1.106R	1.341R
7000	1.005	1.206R
8000	1.087	1.115R
9000	1.154	1.050R
10000	1.209	1.003R
12000	1.294	1.068
14000	1.356	1.119
16000	1.402	1.157
18000	1.438	1.186
20000	1.466	1.209
25000	1.516	1.251
50000	1.611	1.329

The measured energy ratios of equation (3) are thus correlated with the color temperatures by Table 2. With this relationship the tempera-

ture was found from each individual measured energy ratio. These measured temperatures were combined into five point means and plotted in Figure 1B against the spectrophotometrically determined color temperatures. The latter are shown as single measures while the solid line connects the five point mean temperatures of this investigation. A close correlation is shown at the times when both sets of temperatures are available and thus the general outline of the color temperature variations of γ Cassiopeiae may be said to be established. The low temperature near J.D. 2429400 was not indicated by the more scattered temperature determinations published previously.

TABLE 3

ENERGY RATIOS AND TEMPERATURES OF γ CASSIOPEIAE

J.D. 242+	Measured Energy Ratio	Temperature	Mean Ratio	Mean Temperature	Mean J.D. 242+
8256	1.11	13600° K			
8315	1.01	10400			
8342	1.10	13200	1.014R	10550°K	8339
8392	1.16R	7500			
8392	1.11R	8100			
8426	1.09R	8400			
8434	1.10R	8200			
8450	1.09	12800	1.016R	10100°K	8448
8461	1.04	11200			
8468	1.01R	9800			
8477	1.01	10400			
8489	1.11R	8100			
8503	1.00	10100	1.022R	9950°K	8497
8503	1.09	12800			
8511	1.09R	8400			
8515	1.13R	7800			
8539	1.07R	8700			
8539	1.04R	9200	1.074R	8650°K	8542
8550	1.10R	8200			
8567	1.03R	9400			
8592	1.09R	8400			
8592	1.06R	8800			
8608	1.19R	7200	1.096R	8350°K	8617
8633	1.04R	9200			
8659	1.10R	8200			
8692	1.07R	8700			
8706	1.07R	8700			
8721	1.07R	8700	1.128R	8000°K	8719
8735	1.24R	6700			
8741	1.19R	7200			
8746	1.07R	8700			
8748	1.27R	6400			
8759	1.10R	8200	1.108R	8250°K	8759
8771	1.04R	9200			
8773	1.06R	8800			

TABLE 3—(CONTINUED)

J.D. 242+	Measured Energy Ratio	Temperature	Mean Ratio	Mean Temperature	Mean J.D. 242+
8786	1.20R	7100			
8799	1.06R	8800			
8819	1.04R	9200	1.104R	8250°K	8827
8835	1.11R	8100			
8897	1.11R	8100			
8937	1.11R	8100			
8951	1.01R	9800			
8982	1.01R	9800	1.004R	10300°K	8989
9021	1.09	12800			
9052	1.03	10900			
9071	1.03	10900			
9084	1.03R	9400			
9102	1.00	10100	1.014	10650°K	9100
9119	1.04R	9200			
9125	1.11	13600			
9135	1.01	10400			
9142	1.04R	9200			
9166	1.00	10100	1.006R	10250°K	9158
9169	1.09R	8400			
9178	1.10	13200			
9196	1.01R	9800			
9247	1.01	10400			
9294	1.01	10400	1.012R	9950°K	9270
9306	1.03	10900			
9308	1.10R	8200			
9337	1.01R	9800			
9418	1.00	10100			
9445	1.04R	9200	1.032R	9400°K	9429
9468	1.07R	8700			
9479	1.04R	9200			
9490	1.04R	9200			
9514	1.10R	8200			
9525	1.04	11200	1.022R	9700°K	9529
9543	1.00	10100			
9574	1.01R	9800			
9607	1.16	16200			
9662	1.19	18300			
9681	1.16	16200	1.140	15350°K	9671
9700	1.09	12800			
9705	1.10	13200			
9807	1.25	25000			
9820	1.14	15100			
9832	1.07	12100	1.106	14900°K	9846
9846	1.07	12100			
9926	1.00	10100			
9928	1.09	12800			
9935	1.13	14600	1.110	13700°K	9932

After J.D. 2429158 there are no published gradients. The relative energy variations measured on the Michigan spectrograms after J.D. 2429500 show that the energy of the continuous spectrum at 3900 A was far more intense relative to that at 4450 A than formerly. Hence a much higher color temperature is indicated. How high the temperature became is uncertain as this method approaches indeterminacy for temperatures near 20000°K. The highest measured value was 15350°K although it may actually have been considerably higher.*

The color temperatures found in this paper are relative to a small spectral region, λλ 3900 to 4450. A recent spectrogram taken with the Dearborn Observatory low dispersion objective prism gives the impression of broad weak absorption bands in the green to red region. Unpublished photoelectric measures by Hall[6] giving intercomparison energy measures between Vega and γ Cassiopeiae from October, 1935, to October, 1939, show that there is a great deficiency of infra-red radiation. Hall's measures cover too broad regions of the spectrum to show fine details. A series of absorption bands in the visual and infra-red could easily produce an apparent color temperature far higher than that derived from the blue end of the spectrum.

A spectrophotometric intercomparison of energies between γ Cassiopeiae and ε Cassiopeiae on July 14, 1940 (J.D. 2429825) by Williams[7] leads to similar conclusions. The energy curve between λλ 4800 and 4000 was smooth; its gradient was 1.07 based on Williams' 1.19 zero point, corresponding to a temperature of 16200°K which agrees with the high temperature found by the author. The spectrum from λλ 4800 to 6000 was very much more broken up. Neglecting the much larger energy residuals obtained by determining a gradient from the entire spectral region, λλ 4000 to 6000, the corresponding temperature was 21000°K. It seems probable that some absorption features are present which effectively increase the color temperature considerably when it is measured from the visual and infra-red regions of the spectrum. Another possibility is that there is operating some mechanism which causes wide departures from the black body energy curve, but this difference is opposite to the direction postulated by Kosirev[8] for stars with extended atmospheres. According to him, the color temperature should increase toward the violet and ultraviolet end of the spectrum.

It is questionable how well the color temperatures correlate with the

*In the *Astrophysical Journal* of May, 1941, W. Albert Hiltner of the Observatory of the University of Michigan published a series of color temperatures of γ Cassiopeiae. They covered the period of September 21, 1939, to February 9, 1941 (JD 2429528 to 2430035). The temperatures varied between 35500° K and 16000° K, based on the Ann Arbor zero point of the color temperatures scale as determined by R. C. Williams.

These temperatures are considerably higher than those determined by the method of this paper, but do come at the time when the temperature was found to be high by the author. As this method approaches indeterminacy for high temperatures it was suggested in the text that the values might be too low. Hence, an essential agreement is indicated.

effective photospheric temperatures. However, the spectral lines show evidence of a higher state of excitation in 1940[9] when the color temperature was high than when the color temperature was lower, *e.g.*, numerous absorption lines of FeIII and HeI appeared in a shell spectrum. In 1937 many low temperature emission lines appeared[10] although the HeI lines were also strengthened. This was at a time of low color temperature.

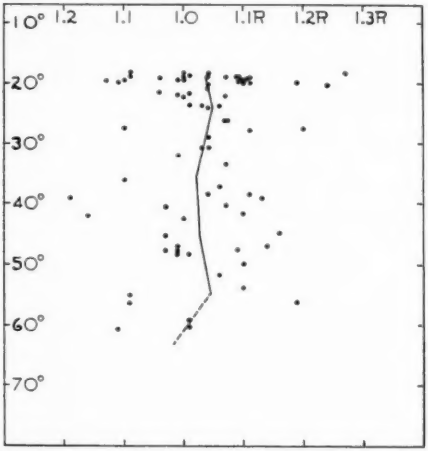

FIGURE 2

Relation between zenith distance of γ Cassiopeiae when spectrum was taken and measured energy ratio. No correlation is observed.

It should be emphasized that the method employed in this problem is fraught with uncertainties. It has only been attempted because there were available numerous well-determined color temperatures which allowed a more or less complete check over parts of the derived temperature curve. The measured temperature curve is continuous, a conclusion which could not be determined from the published gradients. The data are also homogeneous; the spectrograms were all taken on Process emulsion with an aluminum on glass reflector and a one prism spectrograph, and they formed a continuous time sequence.

Two questions will immediately arise. First, is the effect of the earth's atmosphere eliminated statistically? Figure 2 answers this question affirmatively as there is no correlation between the measured energy ratio and the star's zenith distance. Second, are there systematic effects operating to swing the whole temperature curve up or down, wholly, or in part? This possibility is eliminated as a series of spectrograms of π Aquarii covering the same time interval was measured in the same manner and no systematic trends were noticed. As far as could be told the measured

energy ratios in the spectrum of π Aquarii remained constant. This star is not known to be a temperature variable.

In a recent paper in POPULAR ASTRONOMY[11] the photoelectric light curve of γ Cassiopeiae was compared to one determined visually. The effective wave-length of the photoelectric magnitudes is about 4200 A and that of the visual measures is perhaps 5500 A. Consequently, temperature changes should produce systematic differences between the two curves. These differences in magnitude are observed, at one time

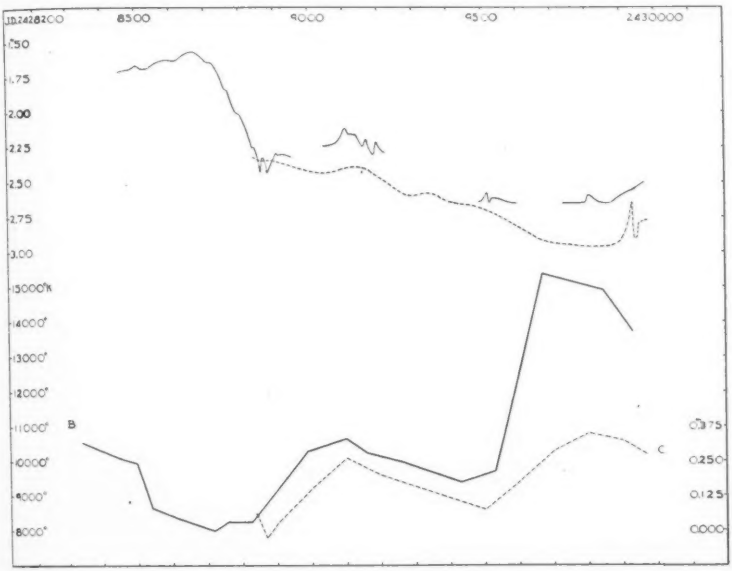

FIGURE 3

The upper solid line represents the photoelectric light curve of γ Cassiopeiae. The broken line is a mean visual light curve obtained by averaging the AAVSO curve and one found by Robert Torp-Smith and the author.

B. Temperature curve from Figure 1B.

C. Differences in magnitude between the photoelectric light curve and the visual light curve in the sense visual minus photoelectric. There is a definite correlation between this curve and the temperature curve. The photoelectric magnitudes are much brighter relatively, when the temperature is higher.

in 1940 amounting to 0.35 magnitude. The light curves are reproduced in the upper part of Figure 3, the visual curve is the best curve determined from the AAVSO curve[12] and one by Torp-Smith and the author. The observed Δm curve is shown in Figure 3C in comparison with the color temperature curve, Figure 3B, and is very evidently correlated with the latter.

I wish to express my appreciation to Dr. H. D. Curtis and Dr. D. B.

McLaughlin of the Observatory of the University of Michigan for lending me the long series of spectrograms of γ Cassiopeiae and π Aquarii, and to Dr. C. M. Huffer of the Washburn Observatory of the University of Wisconsin for sending me his unpublished photoelectric magnitude measures, and to Dr. John Hall of the Amherst College Observatory for the use of his photoelectric spectral energy determinations.

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DEARBORN OBSERVATORY, NORTHWESTERN UNIVERSITY, MAY 2, 1941.

Is the Universe Infinite?*

By PHILIPP FRANK

If we say that the Universe is "infinite" we may express our amazement or our reverence towards the spectacle of the nightly sky full of glittering stars, and still more of dark space which separates these lights. Are these dark lanes just a curtain which hides a still more brilliant spectacle of stars, or do we look through these dark lanes into the empty world space where no stars, no suns, and no matter exists? Are we on the sole island of matter and life in the Universe, or are we on a sample island which repeats itself again and again at different parts of the world space?

I am not going to speak here on "infinity" as an expression of admiration and adoration, but on "infinity" as a term used in science. Is this word which is so endowed with emotional connotations really a word which can be used by a sober scientist? Even in mathematics we use this word. We say: if we consider the series of integers: one, two, three, etc., we can never reach the end; this series is "infinite." Or: we consider a part of a straight line and try to determine the number of points

*Broadcast from station WRUL, in the series of Harvard Radio talks, on May 3, 1941. For other talks in this series, see POPULAR ASTRONOMY for April, 1941, p. 191, May, 1941, p. 236, June, 1941, p. 311, and August, 1941, p. 365.

between the ends of the part which may be only one inch long: then we shall find the number of those points is "infinite."

In any case we employ the word "infinite" if we have to do with a multitude of things which we cannot exhaust by the procedure of counting. But both our examples—the series of integers: one, two, three, etc., and the points between the ends of a line are created by human skill and imagination in order to serve as tools in our eternal struggle for the control of nature. The yard-stick with its points as well as the series of whole numbers is a man-created tool which helps us to bring the phenomena of nature nearer to the human mind and under human control.

We are makers of those tools ourselves and therefore we can be sure of how they are made. We know that we have an infinite number of terms in the series of whole numbers and an infinite number of points on a segment of a line.

But how is it if we have to do with things which are not the creation of our mind but have an independent existence in nature? Can we apply here also the word "infinite" in the scientific sense? What does it mean if we say that the number of stars is "infinite" or, still more puzzling, that the extension of the Universe or of the world space is "infinite"?

We have to start with some procedure of counting or measuring, and to investigate whether the number of stars or the extension of space can ever be exhausted by this procedure. If there is reason to believe that it cannot be exhausted we say the number of stars is "infinite," or the extension of the world space is "infinite."

If we speak of the "infinity" of the Universe, this term can have two different meanings. Do we mean to say that the extension of the whole world space is "infinite"? Or do we mean that the number of stars in this space is "infinite"?

Speaking of the first meaning the general belief among educated people is that an idea of a "finite" space is absurd. For a "finite" space is always bounded by walls or some other boundaries. But what is behind these walls? Space too, of course. Therefore there may be bounded parts of space, but the world space itself cannot be bounded and therefore not "finite." We shall see soon that it is premature to establish this conviction too quick and too firmly.

As to the question whether the matter in the world space is "infinite" or "finite" there seems not to be a general common opinion; a Gallup poll would hardly give a united vote. However, we can see very easily that the existence of an isolated island of matter of finite dimensions and containing a finite number of stars surrounded by an infinite world space seems hardly in agreement with the established laws of nature.

If we consider a vessel filled with air and open a connection with a large vacuum (*i.e.* with a large empty space) the air will dissipate into empty space and will be rarefied the more, the larger the space is. If all stars were located within a limited region of space surrounded by the

infinite world space the stars would in the same way dissipate into the empty space. If this space is moreover "infinite" the stars would behave like a finite quantity of air, streaming into an "infinite" space. The density of the air would become smaller and smaller and finally almost zero. The stars considered as a heap behave, roughly speaking, like the particles of air. In both cases no forces exist which would attract the particles of air or the stars towards each other. The force of gravitation is effective in a solar system, but hardly observable among the distant stars of the Universe. If we assume that our Universe has existed already for an infinitely long time from all eternity this rarification of the stars must already have taken place and our finite island Universe had already dissipated into the infinite world space. Since this is obviously not the case and we enjoy still the light of the stars it seems hardly probable that our Universe of stars is a "finite" island of matter within an empty "infinite" world space.

If we do not speculate but make observations about the location and distances of the stars in the sky we may look for some evidence for or against the assumption that the stars we see in the sky are just an island of matter in an ocean of empty world space. But to find any kind of evidence seems to be very hard. Everybody knows the large agglomeration of stars which is called the Milky Way or the Galaxy. Astronomers have regarded it as a whole as a formation which has the shape of a flat lens or of a watch. A view was held for a certain time that this watchlike agglomeration of stars may be the only island of matter within the infinite world space. The general opinion was that our sun with all the planets are nearly in the centre of this disc. This assumption saved for men at least some of the satisfaction they used to derive from the old geocentric hypothesis, according to which our earth was to be the centre of the Universe. Now our planetary system was regarded as the centre of the Universe. Our earth has at least the satisfaction to be an attendant (a servant) of the central object, the sun. We shall see soon however that also this faint satisfaction turned out to be vain.

Outside the Milky Way we see a great many faint celestial objects. It was unknown for a long time whether they were at the same distance from us as the stars of the Milky Way or at an entirely different distance which may perhaps be a million times greater. It could not be decided whether these stars sent to us so little light because they are so distant or because they do not emit much light altogether.

If we are in a dark forest at night and look for shelter, we may see a twinkling light and venture a guess: does that light indicate to us a house which is near and in which there is a candle burning or is perhaps that faintly twinkling light a forest fire which may be miles away? If we know how to distinguish the light of a candle from the light of a great fire we would be able to estimate whether that light is located near to us or far from us.

Astronomers have noticed that some of the stars we observe in the

extragalactic objects are fluctuating in their brightness. They become periodically brighter and fainter. Each of such stars displays characteristic changes of brightness. Some of them may complete their cycle of variation in one hour, some in one day or a week. We may then investigate some of the similarly varying stars which are within our reach. If we examine more closely the nearest of such stars we notice that the larger and more luminous spheres have longer periods, *i.e.*, are "breathing" more slowly than the smaller ones. This fits into our experiences concerning pulsating mechanisms of any kind. A long pendulum oscillates more slowly than a short one. A long string gives a deeper sound which means slower vibration than a short string. The big contra-bass has a deeper pitch, is oscillating more slowly than the usual small violin with its high pitch and quick oscillations. The high-pitched violin has the same shape but a smaller size than the deep-pitched contra-bass.

Now if we see a light in the dark which is not within our reach, we can nonetheless observe the frequency of the fluctuations of brightness, the periods of the transition between the maximum and the minimum of brightness. If we notice a long period (*i.e.* slow pulsation) we know that we have to do with a large and luminous light source. If therefore we get only little light from that source we can be sure that it is very far away. We are in a similar situation as if we saw in the dark a thing with the shape of a violin, but hear a very deep pitch. Then we can be sure that the sound does not come from a small violin but from a large contra-bass. Even if the instrument is so far away from us that we see it as a very small violin we are sure that in reality it is a very big instrument and that it only seems to be small because it is at a great distance from us.

Professor Harlow Shapley conceived the idea of applying considerations of this kind to decide the question as to what may be the distance of the faint objects which we see outside the Milky Way. If we use a powerful telescope we notice that these faint patches of light are not single stars, but spiral nebulae or globular clusters of stars. Among the stars of these clusters there are quite a few which show periodical fluctuations of brightness. Shapley found that these periods were so long that we must assume that these stars are of a very great size, and therefore of a very high luminosity. Since their apparent brightness is very small it follows that they must be very distant from us or from the flat disc of our Milky Way.

To return to our analogy: they look like small violins, but their deep pitch reveals that they are in reality contra-basses.

The average distance of the globular clusters from the central plane of the Milky Way is about 50,000 light years. This figure can be somewhat visualized if we remember that the diameter of the disc of our Milky Was is about 100,000 light years These clusters convert, so to speak, the flat disc of the Milky Way into a more nearly spherical for-

mation. Outside the flat disc stars, however, are rare like currants in a bun. The greatness of these figures becomes obvious if we remember that the distance from the sun to the earth counts in minutes of light, the distance of the remotest planets in hours of light, and the distance of the nearest star in our Milky Way from us in a few light years.

The investigations of Professor Shapley and his collaborators at the Harvard Observatory gave many important results. It was found that the sun with the planets is not in the centre of the Milky Way but about 35,000 light years away from it, rather near to the edge of the disc. Even the small satisfaction for the inhabitants of the earth of being at least servants of the master of the Universe was gone.

But the investigations of the variable stars led to still more important results. The spiral nebulae resembled by their flat shape the shape of our Milky Way. And the assumption was natural that they may be islands of matter like our own galaxy. But for a long time it was not known really what their distance was. Professor Hubble of the Mount Wilson Observatory and his collaborators found that these nebulae have distances of many millions of light years.

Therefore the observations of the periods of fluctuations of some stars in these nebulae lead to the same result as the speculations I mentioned before. Our Milky Way may not be the only island of matter in an infinite empty space, but just a sample island among many others. The Universe as a whole may be as full and as empty as the region of the sky which can be examined with the naked eye.

We may now assume that the infinite world space is filled up with matter in this way. Is this a satisfactory assumption? We are then surrounded by spheres of matter which become ever larger and larger. The spheres which are very remote exert the same force upon the bodies of our neighborhood as the nearest spheres. For according to the Newtonian law of gravitation the force exerted by a mass becomes the less effective, the farther the mass is removed. But, on the other hand, the action becomes stronger the greater the acting masses are, and the remotest spheres are the largest ones. Therefore, we should have an infinite number of spheres and each of them exerts the same force. The total force exerted upon the bodies of our environment would have to be infinite and they should give rise to infinite velocities. But we observe that all celestial bodies are moving relatively slowly. They have speeds which are small compared with the speed of the light. Therefore it does not seem plausible that the whole infinite world space is filled up everywhere equally with matter.

We have seen that it is neither plausible that this infinite space contains stars and matter only in a restricted region as one island, nor is it plausible that the whole infinite space is filled up with such islands of matter as globular clusters.

Roughly speaking, two ways out of this dilemma were suggested. The first one is an assumption which seems at the first look completely

absurd, namely the assumption that the world space itself is not "infinite" but "finite." This seems to be excluded by common sense itself. It would hardly get any vote at a poll of public opinion.

Nevertheless we can easily understand that the possibility of a finite world space cannot be dismissed without serious consideration.

If we want to investigate whether or not our space is finite we have to examine whether we can measure its size with the aid of yardsticks. We must put them end to end and ask ourselves whether we can exhaust the extension of the space by a finite number of yardsticks. If this turns out to be impossible we say the space is "infinite." Let us imagine such an experiment. We patiently put wooden yardsticks end to end and count their number. It is assumed by popular opinion that, if the Universe were finite we should hit a wall. It would be impossible to continue putting yardsticks beyond this wall. But since behind this wall there must be again space we cannot conclude that the whole world space is "finite." But there is still a different possibility for the outcome of our experiment. It may also happen that by putting yardsticks end to end a thousand times, a million times, a billion times, we should not hit any wall but we should come back to our starting point, to our first yardstick. What would that mean? It would not mean that the world space is "infinite," for we exhaust its extension; it would not mean either that the Universe is "finite" and "bounded" by a wall like Old China, but it means that the Universe is "finite" since we can exhaust and measure its extension, but it is nonetheless not "bounded." Therefore the objection cannot be raised that behind the wall must again be space. The Universe is finite but unbounded: that is a bold assumption indeed, but disposes of a great many difficulties.

The experiment of putting yardsticks end to end billions and billions of times is beyond any established experience, is even beyond our imagination. The outcome cannot be predicted in any way. Therefore it is quite possible that the outcome could support the assumption of a finite and unbounded space. This space could then be filled up with the islands of matter, with the globular clusters and spiral nebulae without leading to the difficulties connected with the assumption of an infinite world space.

It seems very improbable to the majority of people with average school training that by putting yardsticks end to end we can finally come back to our starting point. But this prediction of the outcome of the experiment is only based upon our opinion that anything that is true on a small scale is also true on a large scale. If we do not come back in our experiments on the usual scale we shall not come back either if we employ a billion of yardsticks. But this way of thinking is without foundation. We can regard every small piece of a large circle approximately as a straight line. But we can never regard the whole circle as a straight line. The same logical slip is committed if we suppose, without confirmation, that the outcome of an experiment with a billion of

yardsticks must be the same as with some hundred sticks.

But there is still a second way of meeting the difficulties connected with the distribution of matter in an infinite space. These difficulties start from the assumption that the distribution of matter in the infinite space is stationary. This means that the number of stars in a region of space has remained unchanged through all time.

Perhaps the distribution of island universes undergoes changes in the march of time. There are many reasons to believe that this may be the case. The observations of most distant nebulae give the impression that these nebulae are in a state of recession from our own Milky Way. It seems as if the island universes would be steadily dispersing.

This can occur either in an infinite space or in a finite space. If the world space is finite the thinning up of the distribution of the islands must be accompanied by an increase of the extension of space itself. This means that the number of yardsticks we have to put end to end in order to come back to our starting point is now greater than it was a million years ago and will be still greater after a million of years from today.

In any case, we have seen that the problem of whether or not the Universe is "infinite" has left the domain of pure emotional speculation and entered the domain of scientific research. The outcome is still uncertain, but even the glimpse of the possibility of reaching a decision in a question of this kind may give to the human mind new confidence in its power to penetrate the dark lanes between the stars on which we look with such amazement and awe every night we look at the sky.

Planet Notes for November, 1941

By R. S. ZUG

NOTE: Greenwich Civil Time is employed unless otherwise stated. To obtain Eastern Standard Time subtract 5 hours, Central Standard Time, 6 hours, etc. The planetary phenomena are described as they are to be seen from latitude 45° N. The data are taken chiefly from the *American Ephemeris and Nautical Almanac*.

Sun. Apparent positions of the sun for November 1 and December 1, respectively, are: $\alpha = 14^h\,23^m.2$, $\delta = -14°\,14'.1$; and $\alpha = 16^h\,26^m.7$, $\delta = -21°\,42'.7$. The sun will be in the constellation Libra until November 23, after which it will be situated in Scorpio.

Moon. Phenomena of the moon will occur as follows:

		h	m
Full Moon	Nov. 4	2	0
Last Quarter	12	4	53
New Moon	19	0	4
First Quarter	25	17	52
Apogee	Nov. 5	17	
Perigee	19	2	

Mercury. Mercury will be visible in the morning sky around November 12,

the date of greatest western elongation. It will be situated then in the constellation Virgo, some six or seven degrees to the east of Spica, and may be seen shortly before sunrise. Due to the southerly declination (—9°) of the planet at that time, it will remain relatively inconspicuous.

Venus. Venus attains maximum eastern elongation (47° 16′) on November 23, 5^h, when it will be situated in the constellation Sagittarius. Its low declination of —25° at the time will prevent its being as brilliantly conspicuous as it sometimes is at greatest elongation. Its stellar magnitude will be —4 during November. For the distance of the planet, its angular diameter, etc., reference may be made to page 30 of POPULAR ASTRONOMY for January, 1941.

Mars. Mars will remain an excellent object for telescopic examination during November. On November 1 its angular diameter will be 19″.7, not much less than the maximum at close approach. This will diminish to 14″.2 by the end of the month. Also, the planet's motion in declination brings it north of the celestial equator, and therefore the month of November will probably be the equal of October as far as observation of Mars is concerned, the weather man being charitable. The observer may refer to pp. 30-32 of POPULAR ASTRONOMY for January, 1941, for information enabling him to indentify the surface markings of Mars at any time. Direct motion begins November 12.

An occultation of Mars will occur on November 1 the G.C.T. of the conjunction being $14^h\ 35^m.4$. The occultation will be visible in Asia, India, Australia, and the Malay Archipelago.

Jupiter. Jupiter is nearing opposition and may be found moving in retrograde in the constellation Taurus, to the northeast of Aldebaran.

Saturn. Saturn reaches opposition on November 17, 19^h, at which time its stellar magnitude will be —0.1. The ring system of Saturn is quite favorably oriented for observational study at this opposition. The angular dimensions of the major and minor axes of the outer ellipse of the outer ring will be, respectively, 46″ and 18″, at the time of opposition. Saturn will be found near the western boundary of the constellation Taurus during November.

Uranus. Uranus reaches opposition on November 21, when the planet will be located about 2° south of the Pleiades and just east of the star 14 Tauri. A chart illustrating its apparent motion relative to stars appears on p. 34 of POPULAR ASTRONOMY for January, 1941.

Neptune. Neptune is a morning object situated in the constellation Virgo. Its apparent motion relative to faint stars is illustrated on p. 35 of POPULAR ASTRONOMY for January, 1941.

Occultation Predictions

(Taken from the *American Ephemeris*)

The quantities in the columns *a* and *b* are given for the purpose of making these predictions useful for any place within 200 miles of the point indicated. The procedure is as follows: Subtract the longitude of the point given from the longitude of the place in question; multiply the result in degrees, taking the signs into account, by the quantity under *a* for the star to be observed; similarly, with the latitude, using *b*; apply the sum of the products, with its proper sign, to

the Greenwich C.T., and obtain the predicted Greenwich Civil Time for the phenomenon at the place of observation. To obtain Eastern Standard Time it is necessary to subtract five hours; Central Standard Time, six hours, etc.

Date 1941	Star	Mag.	Immersion: Greenwich C.T.	Immersion: a	Immersion: b	Immersion: Angle E from N	Emersion: Greenwich C.T.	Emersion: a	Emersion: b	Emersion: Angle E from N
Occultations Visible in Longitude +72° 30′, Latitude +42° 30′			h m	m	m	°	h m	m	m	°
Nov. 6	γ Tau	3.9	0 34.7	—0.8	—0.2	136	1 5.3	+0.6	+3.7	195
6	75 Tau	5.3	5 53.9	—2.2	+0.3	87	7 24.8	—2.0	+0.3	250
6	275 B.Tau	6.5	9 53.7	..	..	147	10 30.3	..	..	206
6	α Tau	1.1	10 58.0	—0.5	—1.6	99	12 2.1	—0.2	—1.0	257
8	BD+18°1112	6.4	7 29.1	—2.2	+1.1	72	8 55.4	—2.0	—1.5	290
8	124 H.³Ori	5.7	9 58.6	—1.4	—1.9	116	11 14.4	—1.4	—0.8	256
9	110 B.Gem	6.2	7 52.1	—2.2	+2.7	52	8 57.3	—1.9	—2.9	319
12	ξ Leo	5.1	5 37.5	—0.6	—1.1	152	6 18.6	—0.4	+3.1	231
13	48 Leo	5.2	12 18.3	—1.6	—1.3	123	13 37.5	—1.6	—1.4	287
14	83 Leo	6.5	11 38.3	—1.9	+0.2	99	12 54.2	—1.4	—1.5	313
25	λ Cap	5.4	2 49.1	+0.4	+2.6	7	3 17.4	—1.0	—4.1	312
26	167 G.Aqr	6.4	2 54.6	—0.7	—0.4	63	3 59.8	—0.4	—0.8	252
26	96 Aqr	5.7	21 6.2	—1.6	+1.2	90	22 20.0	—1.4	+1.9	221
30	25 Ari	6.5	22 34.3	..	..	6	23 7.9	..	..	310
Occultations Visible in Longitude +91° 0′, Latitude +40° 0′										
Nov. 6	γ Tau	3.9	0 28.9	+0.1	+0.4	123	1 7.2	+0.5	+2.5	210
6	70 Tau	6.4	3 38.7	..	..	142	4 6.9	..	..	186
6	75 Tau	5.3	5 15.6	—1.7	+1.5	77	6 44.0	—2.0	+1.1	252
6	α Tau	1.1	10 48.4	—1.0	—2.4	120	11 52.2	—1.1	0.0	234
7	115 Tau	5.3	11 58.3	..	..	26	12 27.4	..	..	339
8	BD+18°1112	6.4	6 50.2	—1.7	+1.8	71	8 16.8	—2.2	—0.1	280
8	124 H.³Ori	5.7	9 30.5	—2.1	—2.8	135	10 39.8	—2.4	+1.5	231
9	110 B.Gem	6.2	7 13.3	—1.4	+2.8	55	8 23.6	—2.1	—1.2	306
12	ξ Leo	5.1	5 32.7	—0.2	—0.8	148	6 10.3	+0.2	+2.6	231
13	48 Leo	5.2	11 55.5	—1.2	—2.3	154	13 0.4	—2.5	+0.8	255
14	83 Leo	6.5	11 10.4	—1.2	—0.2	125	12 25.6	—1.7	+0.1	284
14	τ Leo	5.2	11 56.0	—1.4	—0.7	130	13 12.6	—1.9	—0.1	281
21	BD—19°5182	6.4	23 21.2	—1.6	—1.6	116	0 17.5	—0.5	+0.2	225
26	167 G.Aqr	6.4	2 37.3	—1.1	+0.4	51	3 49.5	—1.1	—0.9	259
26	96 Aqr	5.7	20 41.6	—0.8	+1.5	87	21 50.7	—1.1	+2.0	232
Occultations Visible in Longitude +120° 0′, Latitude +36° 0′										
Nov. 6	70 Tau	6.4	3 11.2	—0.1	+0.6	112	3 58.9	+0.2	+2.4	219
6	75 Tau	5.3	4 42.2	—0.2	+2.2	55	5 49.1	—1.2	+1.0	273
6	264 B.Tau	4.8	6 3.3	..	..	136	6 40.3	..	..	191
6	α Tau	1.1	10 7.4	..	..	144	10 50.8	..	..	198
7	115 Tau	5.3	10 47.4	—2.4	+1.2	63	12 13.3	—2.0	—2.0	292
8	BD+18°1112	6.4	6 16.3	—0.2	+2.4	55	7 19.9	—1.3	+0.4	290
8	124 H.³Ori	5.7	8 27.9	..	..	138	9 21.0	..	..	211
9	110 B.Gem	6.2	6 45.9	+0.2	+3.1	41	7 33.3	—1.3	—0.6	313
14	83 Leo	6.5	10 51.9	—0.4	—1.3	153	11 37.6	—0.9	+2.3	245
14	τ Leo	5.2	11 37.3	—0.4	—3.2	171	12 10.7	—1.4	+3.9	230
24	95 B.Cap	6.0	4 55.4	—0.8	—1.1	92	5 53.2	0.0	+0.1	230
26	167 G.Aqr	6.4	1 55.0	—1.0	+2.8	18	2 57.2	—3.1	—1.4	290

METEORS AND METEORITES

Meteor Notes from the American Meteor Society

By CHARLES P. OLIVIER, President

In examining the data which follow, it will be seen that we have information on rates which will help to determine the space-density of four and possibly five of the larger meteor streams. The Lyrids, Eta Aquarids, Pons-Winnecke meteors (?), Delta Aquarids and Perseids are referred to. The reports from Professor Khan, in India, indicate that the first mentioned stream was slightly stronger than reported here, and that he was able to observe quite a good return of the Eta Aquarids. A further report on these comes from our Connecticut group, but they were badly hampered by clouds. The June reports give also higher rates than usual for our excellent observer, Paul Anderson, in Michigan. I have not studied these maps, nor indeed other maps which accompany so many of the records, for radiants, so am as yet unable to pass on the relative number of shower and sporadic meteors. I hope to do this for the next Notes. Both Anderson and W. A. Borden, also of Michigan, found excellent rates late in July, probably showing that the Delta Aquarids returned well. Also on July 27 four groups of the Amateur Astronomers of the Franklin Institute, who have on several previous occasions undertaken simultaneous work for parallax from two or more stations, occupied four stations for the Aquarids. Group I consisted of A. Eichelberger, B. Fahy, E. Baily, L. Smith, and R. Shutts; Group II, of E. Klein, R. Gorson, F. Shaffer, and S. Sprunger; Group III, of Miss A. Abbotts, J. Sauchak, J. Haag, and J. Conners; Group IV had one observer only, H. Smith. The A.A.F.I. have now for over a year made plans for this type of work, which have often been successful, but the fine thing is that they continue their enthusiastic interest, becoming more skillful each time they observe. In this way better and better results can be expected. I hope to find a considerable number of coincidences from which heights can be worked in these observations of July 27.

R. K. Marshall, of the Cook Observatory staff, observing on the night of July 26, secured a superb sporadic meteor at 10:42 E.S.T. with our 10-inch Schmidt camera, focal ratio 1:2.5. This was also observed visually by him. He secured another beautiful meteor on August 17 with a Wollensak Rapid Rectilinear Lens, focal ratio 1:7, focal length 6.25 inches, between 9:43 and 10:35 E.S.T., time of appearance not known as he did not see it visually. We hope to use these cameras for meteor showers which promise enough to make exposures worth while. Unfortunately the Schmidt has a field of only 9° in diameter, so it does not cover very much of the sky.

The Milwaukee Astronomical Society tried similar work on August 12. Their director for meteor work, E. A. Halbach, writes me that he believes "at least 12" merit calculations for heights. They have an excellent radio signal system to insure that the same meteor is being observed at both stations. This Society, by the way, as is well known, owns and runs its own well-equipped observatory and carries on a varied program of real research work. I know of none in the country better organized or more active.

As for the Perseids, moonlight spoiled the display to a considerable degree. Nevertheless, speaking personally, at Flower Observatory on August 10, 12, and 13 the nights were most transparent considering that we are in a brightly lighted

suburb, yet the rates I found were not satisfactory. Added to other reports received, it must be inferred that the return was poorer than usual. Even bright meteors, which could not well be missed, were not numerous. It would be a great pity for the Perseids, the most reliable of all annual meteor showers, to begin to decrease in numbers. However, even a little moonlight makes it difficult to see faint meteors and this may be the basis for my own poor rates and consequent pessimism. Others, whose eyes are younger, saw somewhat more. It is quite certain that reports from distant stations will arrive later.

No society progresses without new members and during 1941 too few have joined us. Numerous persons write me as if doing meteor observing is their dearest wish, but, when they learn they must pay the small $1 annual dues, their enthusiasm vanishes. True we are better off without such persons, who assuredly would do nothing were membership free, but we do need active members in the majority of our states. Certain groups do excellent work; so do some individuals. But knowledge of meteoric phenomena would advance far more rapidly were there good observers in more places. I would welcome suggestions as to how persons, who would really wish to work, could be induced to join our Society.

Station and Observer	Date 1941	Began	Ended	Int.	Met.	Rate	F. *
Begumpet, India, Prof. Khan, Mohd. A.D.	Jan. 1	20:30	21:00	30	12	24.0	0.8
	4	22:15	23:00	45	16	21.3	0.8
	6	21:55	22:25	30	5	10.0	0.6
	28	19:20	20:00	40	8	12.0	0.8
	31	22:12	22:30	18	5	16.7	0.8
					25		
	Feb. 23	23:15	23:50	35	14	24.0	0.9
	24	23:20	23:50	30	10	20.0	0.8
	25	23:00	23:30	30	10	20.0	0.8
	27	22:45	23:30	45	12	16.0	0.8
	28	22:40	23:00	20	9	27.0	0.7
					15		
	Mar. 2	22:45	23:15	30	6	12.0	0.8
	24	15:45	23:00	75	16	12.8	0.8
	25	22:15	23:00	45	8	10.7	0.8
	26	20:15	21:00	45	5	6.7	0.7
					31		
	Apr. 5	21:30	22:30	60	6	6.0	0.8
	6	21:30	22:00	30	6	12.0	0.8
	8	22:40	23:30	50	9	10.8	0.8
	19	21:20	22:00	40	7	10.5	0.6
	21	19:00	20:00	60	17	17.0	0.8
					16		
	May 1	22:50	23:10	20	6	18.0	0.7
	2	20:55	21:30	35	8	13.8	0.8
	3	22:05	22:25	20	7	21.0	0.7
	4	21:45	23:00	75	30	24.0	0.9
	5	21:30	23:00	85	35	24.6	0.8
	6	22:45	23:25	40	21	31.5	0.7
	7	21:50	22:30	40	10	15.0	0.8
Rieglesville, Pa., A.A.F.I., Group 2	June 29	11:00	13:15	135	15	..	0.4 2
Roxborough, Pa., A.A.F.I., Group 1	July 27	11:00	14:01	181	55	..	1.0 5
Rieglesville, Pa., A.A.F.I., Group 2	27	11:10	14:15	185	53	..	0.8 4
Boyertown, Pa., A.A.F.I., Group 3	27	11:24	14:00	156	57	..	1.0 4
Ardsley, Pa., A.A.F.I., Group 4	27	11:00	14:00	180	19	6.3	0.9 1

* In last column a † denotes meteors were counted only or mostly. It may be inferred that most of the rest were plotted. A number, in this same column, refers to how may observers there were. Corrected rates may be obtained by dividing Rate by Factor.

Station and Observer	Date 1941	Began	Ended	Int.	Met.	Rate	F.	*
Stellafane, Vt., Gorson, R.	Aug. 2	12:50	16:30	260	85	..	0.8	2†
New Haven, Conn., Neale, J. J.	Apr. 25	12:47	14:30	103	6	3.5	0.7	
	28	12:45	14:00	75	8	6.4	0.5	
	May 2	14:47	16:00	73	10	8.2	0.8	
	3	11:46	15:55	221	25	6.8	0.7	
New Haven, Conn., Miss Furnald, S.	3	14:14	15:55	101	10	6.0	0.7	
Cheshire, Conn., Scott, P.	2	15:05	16:00	55	12	13.0	..	†
N. Guilford, Conn., Scott, P.	July 26	9:00	13:00	240	29	7.2	0.5	
New Waterford, Ohio, Haas, W.	June 23	12:04	13:15	71	11	9.3	1.0	
	25	11:53	13:04	71	7	5.9	1.0	
	27	10:51	12:04	73	9	7.4	0.9	
	July 25	10:48	12:09	81	16	11.9	0.8	
	28	14:24	15:20	56	19	20.4	0.9	
	Aug. 12	12:28	13:56	88	18	12.2	0.6	
Champaign, Ill., Tapscott, C.	May 26	9:30	11:02	92	9	5.9	0.8	
	28	10:06	10:55	49	6	7.3	0.8	
	June 19	8:45	10:10	85	7	4.9	..	
	July 27	10:55	12:25	90	15	10.0	0.8	
	28	10:51	12:05	74	8	6.5	0.7	
Kalamazoo, Mich., Persons, W. J.	Apr. 21	9:10	12:35	185	15	4.9	0.6	
	22	10:10	12:05	115	8	4.2	0.8	
Kalamazoo, Mich., Champney, M.	21	9:03	13:03	240	30	7.5	..	
Kalamazoo, Mich., Hewett, G.	22	10:05	13:05	180	18	6.0	..	
Birmingham, Mich., Borden, W. A.	Mar. 1	10:15	11:15	60	7	7.0	0.4	
	Apr. 21	11:00	12:40	100	14	8.4	1.0	
	24	11:10	12:00	50	25	30.0	0.8	
Collingwood, N. J., Borden, W. A.	July 15	10:25	11:00	35	7	12.0	0.6	†
Birmingham, Mich., Borden, W. A.	19	10:15	12:16	121	30	14.9	0.6	
	21	10:25	14:10	225	40	10.7	0.6	
	22	10:50	14:30	220	52	14.2	0.6	
	24	10:30	14:50	260	48	11.1	0.6	
	25	12:00	15:00	180	57	19.0	0.6	
Collingwood, N. J., Esher, A. B.	15	10:25	11:00	35	4	6.9	0.6	†
Beechwood, Mich., Anderson, P.	Apr. 21	9:10	10:50	90	22	14.7	1.0	
	23	8:25	10:15	90	15	10.0	1.0	
	24	8:55	9:55	60	10	10.0	0.8	
	May 16	9:35	10:35	60	11	11.0	1.0	
	18	8:58	9:58	60	12	12.0	1.0	
	19	8:55	9:55	60	10	10.0	1.0	
	24	9:15	10:15	60	9	9.0	1.0	
	June 15	9:15	10:15	60	10	10.0	1.0	
	16	9:15	11:00	105	18	10.3	1.0	
	17	9:30	10:00	30	6	12.0	0.8	
	18	10:45	12:45	120	25	12.5	0.8	
	19	12:15	14:30	135	33	14.7	0.9	
	20	12:10	13:40	90	22	14.7	0.7	
	24	11:10	14:40	210	56	16.0	0.9	
	July 20	11:00	12:00	60	12	12.0	0.8	
	21	11:55	13:25	90	23	15.3	0.8	
	23	12:15	13:15	60	18	18.0	0.6	
	24	11:55	13:25	90	23	15.3	0.7	
	25	12:00	12:45	45	10	13.3	0.7	
	26	11:15	15:15	240	85	21.2	1.0	
	28	11:00	13:15	135	68	30.2	0.6	
Upper Darby, Pa., Wetherell, G.	Aug. 12	10:17	14:07	230	40	10.4	0.5	
Flower Obs., Pa., Olivier, C. P.	10	11:03	13:03	120	17	8.5	0.7	
	12	13:10	15:32	142	25	10.6	0.8	
Cook Obs., Pa., Marshall, R. K.	July 26	8:30	14:25	211	19	..	0.7	
	Aug. 12	11:00	15:00	240	29	..	0.7	3
	13	8:19	9:42	..	8	..	0.7	2
Joliet, Ill., Preucil, F.	July 27	8:30	10:00	90	10	6.7	0.8	†

Station and Observer	Date 1941	Began	Ended	Int.	Met.	Rate	F.	*
Fayetteville, Ark., Jamison, A. W.	Aug. 11	8:30	11:30	180	14	4.7	0.9	†
Somers Point, N. J., Woodburn, J. J.	12	9:00	10:50	110	34	18.6	..	†
New York, N. Y., Magruder, G. P.	12	10:			20		0.7	†
Providence, R. I., Euart, J. L.	13	11:30	13:00	120	16	8.0	0.7	†
Manheim, Pa., Graybill, H. A.	10	10:30	12:30	120	9	4.5	0.6	†
Cynwyd, Pa., Miss O'Connell, H.	12	10:15	13:15	180	41	13.7	0.7	†
	12	10:45	12:00	75	9	7.2	0.6	†
Cynwyd, Pa., observer	12	11:00	12:00	70	8	6.8	0.6	†
Lansdale, Pa., Mrs. Radtke, H.	12	12:00	13:00	60	13	13.0	0.8	†
Broomall, Pa., Stroud, W. G.	12	11:02	12:02	60	30	30.0	0.7	†
Mt. Joy, Pa. { Mr. and Mrs. Newcomer, J. D.	12	9:00	11:15	135	43	..	0.7	2
	13	8:	9:	60	10	..	..	3
Philadelphia, Pa., Hamstron, W. B.	12	8:45	10:	75	10	8.0	..	†
Casuals					22			5
Milwaukee Astronomical Society—								
M.A.S. Observatory, Wis., Livingston, D., Saxon, D.	12	9:34	14:04		32	..	..	2
Madison, Wis., Halbach, E. A., Custin, T.	12	8:43	13:20		34	..	..	2
Ball, A. R.	11	11:36	12:36	60	11	11.0	..	†
Toyah, R.	11	9:45	11:32	107	22	12.4	..	†
Lovinus, L.	11	9:45	11:11	86	34	23.8	..	†
Giese, B.	11	11:13	12:35	72	23	19.2	..	†
Toyeh, R.	12	9:06	10:55	109	38	20.9	..	†
Giese, B.	12	9:06	10:55	109	43	23.6	..	†
Moore, D.	12	9:06	10:55	109	25	13.7	..	†
Cape Elizabeth, Me., Dole, R. M.	July 29	11:00	13:25	120	20	10.0	0.5	
Scarborough, Me., Dole, R. M.	Aug. 12	8:22	13:00	160	28	10.5	0.7	
Eugene, Ore., Mrs. Thompson, F.	13	14:00	15:00	60	10	10.0	0.7	†
Eugene, Ore., Miss Thompson, B. J.	13	14:00	15:00	60	6	6.0	0.7	†

Flower Observatory, Upper Darby, Pa., 1941 August 23.

Contributions of the Society for Research on Meteorites

Edited by FREDERICK C. LEONARD,
Department of Astronomy, University of California, Los Angeles

President of the Society: LINCOLN LA PAZ, Department of Mathematics, Ohio State University, Columbus

Secretary of the Society: C. H. CLEMINSHAW, Griffith Observatory, Los Angeles, and Department of Astronomy, University of Southern California, Los Angeles

Report of the Eighth Meeting

By ROBERT W. WEBB, *Secretary, 1937-41*

The Eighth Meeting of the Society for Research on Meteorites was held in Flagstaff, Arizona, on June 23, 24, and 25, 1941. Sessions were held at each of the three host institutions, the Arizona State College, the Lowell Observatory, and the Museum of Northern Arizona. The following 20 members were in attendance at one or more of the sessions of the Society, which were open also to, and were well attended by, other scientists (non-members) and the general public: L. F. Brady (Flagstaff, Arizona), Robert G. Brown (Fort Worth, Texas), C. H. Cleminshaw (Los Angeles, California), Arthur S. King (Pasadena, California), Alfred Knight (Phoenix, Arizona), C. O. Lampland (Flagstaff, Arizona), Leota J. La Paz (Columbus, Ohio), Lincoln La Paz (Columbus, Ohio),

Frederick C. Leonard (Los Angeles, California), H. C. Markman (Denver, Colorado), P. G. McGough (Flaffstaff, Arizona), Ralph I. Meeker, Jr. (Denver, Colorado), Oscar E. Monnig (Fort Worth, Texas), H. H. Nininger (Denver, Colorado), Robert D. Nininger (Denver, Colorado), Edward S. C. Smith (Schenectady, N. Y.), Clyde W. Tombaugh (Flagstaff, Arizona), Robert W. Webb (Los Angeles, California), Walter J. C. Weiss (San Antonio, Texas), and Walter T. Whitney (Claremont, California). Fifty-nine persons, including guests, signed the register at the meeting.

The number of papers read at the meeting was 20. Sixteen of these were presented personally by their authors.

The Society had on exhibition at the meeting a collection of Philippine tektites (lent by Dr. D. T. O'Connell of the College of the City of New York), a collection of Texas tektites and meteorites (lent by Mr. Oscar E. Monnig), and several specimens of various meteoritic falls (displayed by Dr. H. H. Nininger and others).

PROGRAM OF THE EIGHTH MEETING

President H. H. Nininger presiding

Monday, June 23

9:30 A.M., Assembly Hall, Arizona State College. Session for papers, including the welcoming address on behalf of the Arizona State College by Dr. T. J. Tormey, President of the College; opening remarks by President H. H. Nininger; and 6 scientific papers, each followed by a lively discussion. Attendance, 36.

2:00 P.M., Assembly Hall, Arizona State College. Session for papers, including the address of the retiring President, Dr. H. H. Nininger, on "Meteorites and the Moon," which was part of a general session on "Lunar Craters," followed by vigorous discussion by practically the entire audience. Attendance, 35.

7:00 P.M., an informal dinner for members of the Society and their guests, attended by 39 persons, was held at the Monte Vista Hotel, after which President Nininger called on several members to make brief table talks on their experiences in meteoritics. Dr. Harold S. Colton, Director of the Museum of Northern Arizona, extended the welcome of the Museum staff to the Society. The speaker of the evening, Dr. V. M. Slipher, Director of the Lowell Observatory, first welcomed the members of the Society on behalf of his staff and then addressed the audience on "The Earth and Mars"; his subject was illustrated by many excellent pictures.

Tuesday, June 24

4:00 A.M., Lowell Observatory. Mr. Clyde W. Tombaugh discussed the planet Mars in a demonstration with the 24-inch telescope at the Observatory, before members and guests of the Society.

9:30 A.M., Assembly Hall, Arizona State College. Business meeting of the Society, including the report of the President, report of the Secretary, report of the Treasurer, and reports of committees: Endowment (Frederick C. Leonard, Chairman); Terminology (Lincoln La Paz, Chairman); and Membership (Robert W. Webb, Chairman); the Committees on Catalog and the Legal Ownership of Meteorites did not report. The revision of the *Constitution* and the *By-Laws* of the Society, as proposed by the Council for adoption at, and circulated with the call for, this meeting, was duly adopted by unanimous vote of some 42 members, cast largely by mail. These new instruments became effective upon the adjournment of the Eighth Meeting. The election of the Council for the 1941-45 term was reported by the Secretary, all the candidates nominated by the retiring

Council (*C.S.R.M.*, **2**, No. 4, 272-3; *P. A.*, **49**, 216-17, 1941) having been elected by vote of the members. A resolution of appreciation to those responsible for the conduct of the meeting was passed as follows: "The Society expresses its deep appreciation to the host institutions, the Arizona State College, the Lowell Observatory, and the Museum of Northern Arizona, and to the Committee on Arrangements for the Eighth Meeting, individually and as a group, for their efforts, trouble, expense, and hospitality in making this, the Eighth Meeting, the great success it has been."

10:30 A.M., Assembly Hall, Arizona State College. Session for papers, highlighted by the discussion of instrumental meteorite-detecting, following the presentation of papers on this subject. Attendance, 29.

1:30 P.M., Lowell Observatory. Informal visit to the grounds and buildings of the Observatory.

2:30 P.M., Meeting of the retiring Council of the Society at the Museum. (Present, 6 members: the President, the Secretary, the Treasurer, the Editor, Councilor (President-elect) La Paz, and Councilor Whitney; and, by invitation, Secretary-elect Cleminshaw and Councilor-elect Monnig.)

3:30 P.M., Museum of Northern Arizona. Session convened to hear the address by retiring President Nininger on "A Look Ahead: A Proposed Program of Meteoritical Research." Other highlights included inspection of the Museum, the staff of which served refreshments to members of the Society and their guests, and a popular lecture on "Immigrants from Space," delivered by Dr. Frederick C. Leonard. Attendance, 45.

8:00 P.M., Lowell Observatory. Informal inspection of the library and observations through the 24-inch refractor of the Observatory; Director Slipher at the telescope.

Wednesday, June 25

10:00 A.M., Field trip to the Meteorite Crater of Arizona. Luncheon was served within the Crater rim by the Committee on Arrangements for the meeting.

1:00 P.M., Session for papers, within the Crater rim, highlighted by discussions of the problem of the origin of the Crater. At the close of the session, the incoming President, Dr. Lincoln La Paz, was introduced. Adjournment, *sine die*, occurred at 2:30 P.M. After the adjournment of the meeting, a search for surface meteorites in the vicinity of the Crater, by members of the party, netted a number of small irons for several fortunate individuals. Attendance, 36.

LIST OF PAPERS READ AT THE EIGHTH MEETING

(The papers are numbered in the order in which they were read.)

Morning Session, June 23

*1. "Small Aërolites Recovered from the Site of the Holbrook, Arizona, Fall of 1912," Frederick C. Leonard, University of California, Los Angeles. Discussed by Messrs. Nininger, Webb, La Paz, Monnig, Brady, Lampland, Tombaugh, and Brown.

*2. "A Recently Discovered Aërolite from Rosamond Dry Lake, California," Walter T. Whitney, Pomona College, Claremont, California. Discussed by Messrs. Nininger, Leonard, Monnig, Tombaugh, Brown, and La Paz.

*3. "The Determination of the Precise Location of the Travis County, Texas, Meteorite Find of 1889," Oscar E. Monnig, Fort Worth, Texas. Discussed by Messrs. Nininger, Brown, Tombaugh, Knight, Webb, and Leonard.

*4. "A Case of Faulting in an Iron Meteorite," H. H. Nininger, Colorado

Museum of Natural History and American Meteorite Laboratory, Denver. Discussed by Messrs. Monnig, Tombaugh, Meeker, Murdoch, La Paz, and Brown.

*5. "The Schertz, Guadalupe County, Texas, Meteorite Proved Identical with Canyon Diablo, Arizona," Oscar E. Monnig. Discussed by Dr. Nininger.

6. "Note on Contraterrene Meteorites," C. C. Wylie, University of Iowa, Iowa City. (Read by Robert W. Webb.) Discussed by Messrs. La Paz, Monnig, and Nininger.

Afternoon Session, June 23

*7. "Meteorites and the Moon" (Presidential Address), H. H. Nininger. Discussed by Messrs. Tombaugh, Monnig, Leonard, Whitney, Cleminshaw, and Lampland.

*8. "Meteorites in their Bearing on the Origin of the Surface Features of the Moon," Clyde W. Tombaugh, Lowell Observatory, Flagstaff, Arizona. Discussed by Messrs. Adel, Lampland, Nininger, Webb, Monnig, Meeker, Murdoch, and Cleminshaw.

*9. "Comments on the Spectra of Two Bright Meteors," C. O. Lampland, Lowell Observatory, Flagstaff, Arizona. Discussed by Messrs. Adel, Nininger, and Lampland.

Morning Session, June 24

*10. "Meteorite Detection," Lincoln La Paz, Ohio State University, Columbus. Discussed by Messrs. Monnig, Nininger, Brown, Tombaugh, Knight, McGough, and Murdoch.

11. "Synthetic Symmetry in Meteorite Detectors," Franklin Wisman, Ohio State University, Columbus (introduced by Lincoln La Paz). (Read by title.) Discussed by Dr. La Paz.

*12. "A Supplementary Test for Meteorites," Oscar E. Monnig. Discussed by Messrs. Leonard, Nininger, Markman, and Whitney.

*13. "Statistical Studies of the Meteoritic Falls of the World: 3 Their Time Distribution," Frederick C. Leonard with Boris Slanin.

*14. "Petrographic Notes on Some Pantar, Lanao, Philippine Islands, Aërolites," Ralph I. Meeker, Jr., Denver, Colorado.

Afternoon Session, June 24

*15. "A Look Ahead: A Proposed Program of Meteoritical Research," H. H. Nininger.

Afternoon Session, June 25

*16. "Announcing the Recent Discovery of a Probable Meteorite Crater in Colorado," H. H. Nininger.

17. "Progress in Excavating the Odessa, Texas, Meteorite Crater," E. H. Sellards and V. E. Barnes, University of Texas, Austin (an invited paper). (Read in abstract by Robert W. Webb.)

*18. "Statistical Studies of the Meteoritic Falls of the World: 4. Their Mass Distribution," Frederick C. Leonard with Boris Slanin. (Read by title.)

*19. "The Determination of a Lower Bound for the Mass of the Pasamonte, New Mexico, Meteorites," Lincoln La Paz.

20. "On the Distribution and the Probable Origin of the Lunar Craters," William Scott, Ohio State University (introduced by Lincoln La Paz). (Read by Lincoln La Paz.)

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*Papers marked with an asterisk were presented personally by their authors.

Report of the Secretary of the Society for the Term 1937-41*

By ROBERT W. WEBB

The Society is, with this, the Eighth Meeting, closing its second administration. As the retiring Secretary, I am presenting some facts regarding the Society that should be of interest to all members and fellows.

On June 1, 1941, the Society numbered 127 active members, representing a nearly stable membership composed largely of persons genuinely interested in meteoritics. Of this number, 71 were fellows, having been elected by the Council in this administration and the preceding, from outstanding professional men in the field. This number (71) represents 56% of the active membership, showing the definitely professional status of our Society. Of the members, 19 live in countries other than the continental United States. Foreign members are fewer than are desired, numerous invitations to membership having been declined for financial reasons. Interest has been expressed by many foreign correspondents in the work of the Society; their inability to coöperate is due often to national restrictions within the countries in which they reside. The Council, at its meeting in Los Angeles, California, on April 14, 1939, approved a plan of deferred action in the case of foreign members, delinquent because of national restrictions. The Secretary and the Treasurer have administered this provision accordingly. During the term 1937-41, 55 persons have been admitted to membership in the Society. In the same period, 24 have officially resigned, and 28 have been declared delinquent, according to the provisions of Art. 4, Sect. 4, of the *By-Laws* of the Society. Seven members have died since the inception of the Society; namely, James S. Andrews, Rutherford, New Jersey; Gavin James Burns, London, England; Oliver Cummings Farrington (the Honorary President), Chicago, Illinois; Shirl Herr, Crawfordsville, Indiana; George Irving Hopkins, Manchester, New Hampshire; E. H. Luschi, Oelrichs, South Dakota; and Walter B. Scaife, Oakland, California.

Analysis of the figures presented indicates that though the total membership of the Society has not materially increased in the past 4 years, progress has been made, in that newly elected members are genuinely concerned with the future of meteoritics and of the Society, whereas those replaced were largely only passingly interested in something new and unusual. My analysis indicates stability of membership from now on, the formative period of organization, membership, and control being effectively behind us. This fact is indicated by the following analysis of delinquencies: 1933-37, 71 members delinquent; 1938, 16; 1939, 4; 1940, 8. In summary, on June 1, 1941, the membership of the Society was as follows: 127 active members, including 71 fellows, 14 charter members and fellows, and 2 patrons.

The Secretary's office, charged with the distribution of the publications of the Society, has sent each year copies of the CONTRIBUTIONS to 161 institutions, designated as depositories by the Council. The Secretary's office has available for distribution, at $2.00 per copy, all the issues (annual fascicles) of the CONTRIBUTIONS. However, very few copies of Vol. 1, Nos. 1 and 2, for 1935 and 1936, respectively, remain. The Secretary holds all the available stock of O. C. Farrington's book on *Meteorites* (1915), of which 59 copies have been sold from 1937 to 1941 June 23.

In conclusion, the retiring Secretary offers the following suggestions for the future program of the Society: (1) A membership campaign should be con-

*Read at the Eighth Meeting, Flagstaff, Arizona, June 23-25, 1941.

tinued at all times, designed particularly to invite the coöperation of foreign workers in scientific fields. Only by constant attention can a stable and an active membership be maintained. Above all, no one engaged in meteoritical work should be overlooked in attempting to build up the membership of the Society. (2) The participation of the Society in meetings with the American Association for the Advancement of Science, with which it is affiliated, should be encouraged, especially through the arrangement of joint sessions with the Sections of the A.A.A.S. (D and E) that have fields of common interest to ours. Coöperation with other organizations, also, should be encouraged. (3) Local interest in meteoritics should be fostered and regional branches of the Society should be established, in accordance with the provisions of Art. 7 of the *By-Laws* of the Society.

VARIABLE STARS

Variable Star Notes from the American Association of Variable Star Observers

By LEON CAMPBELL, Recorder

Eclipsing Variables in the Magellanic Clouds?: The question has often arisen, do eclipsing variables inhabit the Magellanic Clouds? Perhaps this question is to be answered by the recent investigations made by the Harvard Observatory staff members who announce the discovery of ten eclipsing stars in the region of the two Clouds.

It is well known that eclipsing binaries of high luminosity are relatively infrequent, whatever their spectral class, especially those which have periods between one and ten days. Excepting for the low luminosity W Ursae Majoris stars, most eclipsing stars are of spectral class A, and their absolute magnitudes range mostly between zero and plus three.

Nearly 700 variable stars have been studied in the two Clouds, of which ten are definitely known to be eclipsing binaries. Four are in the Large Cloud and six in the Small Cloud. Their periods range from 1.77 days to 66.9 days; four have light curves resembling Algol, and six resemble that of Beta Lyrae.

In spite of the fact that these ten eclipsing stars are situated in the relatively large area of the sky covered by the Magellanic Clouds, there is a strong probability that they are merely superposed upon the clouds and are not intrinsic parts of them. If they do belong to the Clouds, their absolute magnitudes at maximum would be surprisingly high ($-1^{M}.4$ to $-3^{M}.2$) for eclipsing stars of average period length and typical light curve. However, Harvard Variable 1346 in the Small Cloud, with a period of sixty-seven days, may well belong to that Cloud. Its absolute photographic magnitude of —1.7 at maximum may not be too bright for a giant, long-period, eclipsing variable.

Increase in brightness of Z Andromedae, 232848: The peculiar variable star, Z Andromedae, has been very assiduously observed in recent years, especially since the maximum of 1939, when the star attained a mean visual magnitude of 7.9. During 1940 the star gradually decreased in brightness to magnitude 9.6 and it has now again increased to magnitude 8.5 at the beginning of September of this year. The minimum magnitude is usually about eleven with marked fluctuations at that phase. The possible periodicity of 650 days suggested by Dr. R. Prager

appears to be again indicated in view of the fact that approximately 700 days have elapsed since the corresponding magnitude was attained in 1939.

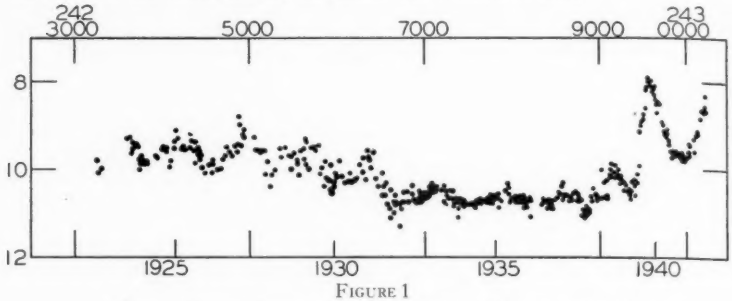

FIGURE 1

VISUAL LIGHT CURVE OF Z ANDROMEDAE (10-DAY MEANS).

The recent spectrum, as described by Struve and Swings, shows that the emission lines of Si II and Mg II, 4481, predominate, and that the absorption lines of H and He I are somewhat more conspicuous than in August, 1940, and January, 1941. The spectrum is decidedly unlike that of the maximum of 1939.

The system of Z Andromedae has been described as consisting of a "Z star" and a "Z Nebula," with one component of the "Z star" a bright line star and the other a super-giant with the outer atmosphere having a radius possibly greater than that determined for α Orionis and α Scorpii. The semi-periodic outbursts would appear to be confined mainly to the bluer component of the system.

The light curve, as observed visually from 1923 to date, is shown in Figure 1.

SS Cygni: The peculiar variable SS Cygni has been under observation now for forty-five years, ever since its discovery at Harvard Observatory by Miss L. D. Wells in 1896. During these years 56,900 observations have been made on 13,312 nights, or on 81 per cent of all possible nights. If we divide the forty-five years into five groups of nine years each, we find that the totals for each group are 4069, 9015, 14930, 15666, and 13326, respectively. During the years 1915 to 1934, inclusive, the annual number of observations averaged 1747, on 93 per cent of all the available nights.

The completeness of the light curve during this long span of years, particularly during the past thirty-five, has been due mainly to the efforts of the amateur variable star observers, especially those of the British, American, French, and Danish organizations.

It is very certain that all but one of the 323 maxima have been observed in whole or in part. To be sure some doubt as to the type of maximum observed may exist but sufficient data have been secured to indicate where these maxima occurred on the light curve.

The average length of a cycle over these years has been 50.7 days, with extremes of 22 and 102 days. The average cycle for each ten-year interval, 1900 to 1910, 1910 to 1920, etc., is $46^d.6$, $50^d.4$, $52^d.8$, and $52^d.1$, respectively. There would thus appear to have been a lengthening of cycle during these forty-five years. Such an increase is also noted if we determine the number of days occupied for each group of fifty cycles; a gradual increase from 48 days to 53 days is indicated.

In the earlier discussion of the variable, which referred to the years 1896 to 1933, inclusive, it was found that the various types of maxima could be divided into four distinct classes, depending mainly on the rapidity of the rise from minimum to maximum: A, the very rapid rise; B, somewhat slower; C, moderately slow; and D, decidedly slow. These classes were further subdivided, depending on the breadth of maximum across the curve at magnitude 10.0: type A-1 to A-10; B-1 to B-4; C-1 to C-6; and D-1 to D-4.

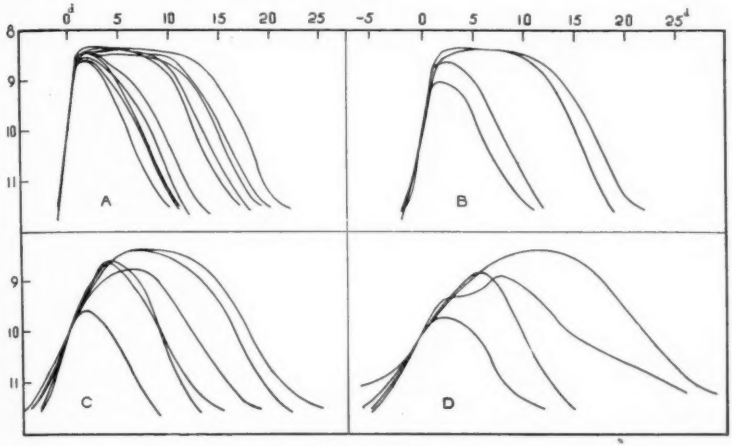

FIGURE 2

TYPICAL FORMS OF MAXIMA OF SS CYGNI.

The A-type maxima have numbered 189, or 59 per cent of the whole; B, 34, or 11 per cent; C, 65, or 20 per cent; and D, 33, or 10 per cent. Of the A-type, those of A-8 have been the most numerous, 33 in all or 18 per cent of the A-type. Those of A-4 and A-7 have occurred nearly as frequently, numbering 27 and 29, respectively. The various types of maxima are illustrated in Figure 2.

The variety of types shown by SS Cygni is quite in contrast to that for U Geminorum. For the latter only two types have been observed, narrow and wide, and these almost invariably alternate. Such regularity can not be said to prevail for SS Cygni when we find every possible sequence of types. U Geminorum has a mean cycle about twice as long as that for SS Cygni and a range in variation which exceeds that of the latter by a full magnitude; approximately five magnitudes (9 to 14) for U Geminorum, and four magnitudes (8 to 12) for SS Cygni.

Personal: Mr. Mark Howarth, an ardent variable star observer of Mayfield, Newcastle, Australia, was the independent discoverer of Comet van Gent. He noted the presence of a nebulous object on June 16, 1941, while observing the long-period variable W Scorpii, and observations an hour or so later revealed it as a comet of about the tenth magnitude.

Observers and Observations received during July and August, 1941:

Observer	July Var.	July Obs.	August Var.	August Obs.
Albrecht	14	17		
Ashbrook			8	8
Ball, A. R.	19	19	16	43
Ball, J.	31	39	31	48
Blunck	27	34	38	51
Bouton	31	38	48	55
Brocchi	10	13		
Buckstaff	9	13	14	34
Cave	4	7	5	9
Chandra	48	76	160	350
Christman			6	6
Cilley	62	202	50	102
Cooke	11	18		
Cousins	58	155	61	151
Dafter	8	20	9	50
Diedrich	1	1	4	4
Escalante	17	17		
Fairbanks	13	19	17	21
Fernald	126	205	167	442
Ford			39	39
Gaebler	2	2		
Geise			3	6
Gillespie	15	24	11	11
Griffin	42	42	7	7
Halbach	112	128	41	69
Harris	39	39	22	22
Hart	13	43		
Hartmann	104	134	57	62
Heckenkamp	5	8	22	22
Hiett	12	23		
Hildom			18	18
Holmes (Mrs.)	4	4	8	8
Holt			86	128
Houghton	75	75		
Howarth	17	18	15	16
Jones	39	146	71	262
Kearons (Mrs.)	61	100	69	124
Kelly	10	13	11	16
de Kock	60	272	52	52
Livingston	26	27	35	52
Lovinus	18	24	9	14
Maher			2	10
Manlin			57	82
Maupome	18	18	15	15
Morey	3	3		
Nadeau	20	35	38	50
Parker	15	15		
Parks	24	49	31	49
Peltier	109	178	126	207
Prinslow	2	5	17	34
Rosebrugh	12	51	11	43
de Roy			5	5
Ryder	7	7		
Saxon	32	37	29	37
Schoenke	13	13	17	61
Schultz (Miss)	17	17		
Sill	54	54	12	12
Smart	42	73	22	22
Smith, F. P.	6	6	8	8
Stahr (Miss)	19	21	20	24
Taulman			33	54
Topham	28	28	27	27
Townsend			12	12
Toyek	6	7		
Treadwell			5	7
Webb	8	8	11	11
Wilson	13	31	15	25
	67	Totals	2667	3100

Comet Notes

By G. VAN BIESBROECK

COMET 1941 *e* (DU TOIT-NEUJMIN). The fifth comet of this year was discovered on July 18 at the southern station of the Harvard College Observatory at Bloemfontein, South Africa, by Mr. du Toit, assistant astronomer. The first information given contained the following data:

1941 July 18 Right ascension 20 hours
Declination —7°
Daily motion 1^m5 east, 1'.5 north
Magnitude 10.

This was cabled to the Central Bureau at the Harvard College Observatory, Cambridge, Mass., and received there on July 27. But instead of transmitting the already delayed information to the subscribing observatories, the Central Bureau held the contents until further confirmation. The opportunity of a month of observation was thereby lost. The object was found independently by Neujmin

at Simeis (Crimea). This gave the following new positions:

	h	m	°	′	Mg.
1941 July 25.87 U.T.	20	9.6	—5	56	
July 29.90		15.5	5	30	9
Aug. 1.91	20	19.9	—5	16	

which were radiogrammed from Moscow to the Central Bureau with the inevitable delays caused by war conditions. It was not until August 22 that the Bureau finally gave out the information received the previous month.

The comet moved rather slowly and it was easily located and observed at several observatories. By the end of August the magnitude was reduced to 11. I observed it here with the 40-inch refractor on August 29 as a round coma some 45″ in diameter, centrally condensed into a fairly sharp nucleus. There was a faint tail visible over a length of 3′ in position angle 105°, nearly opposite to the direction of the sun. On the following days there was an evident decrease of brightness. It will take some time before the future course can be predicted safely because of the crude nature of the earlier data. The following first orbits are available at this time:

ELEMENTS OF COMET DU TOIT-NEUJMIN

	Scott and Stahr Berkeley	A. D. Maxwell Ann Arbor	Willis Naval Obs.
Node to perihelion	83° 12′	82° 37′ 38.″1	69° 51′
Node	142 33	217 42 23.9	229 6
Inclination	175 28	4 31 40.8	3 17
Perihelion distance	1.7528	1.477019	1.30829
Time of perihelion	July 23.089	July 22.71612	July 21.362
Eccentricity	1	1	0.5893

The latter computer arrived at the small value of 5.686 years for the period, which would make the aphelion distance only 5.06. This is extremely indeterminate in view of the short arc observed. It is, however, already certain that the brightness will continue to decrease and that in October the comet will move slowly eastward across the constellation of Aquarius as shown by the following ephemeris given by Maxwell.

EPHEMERIS

1941	h	m	°	′	Distance from Sun	Distance from Earth
Sept. 27	21	41.7	—6	3	1.74	0.84
Oct. 5	21	53.29	6	2	1.80	0.94
13	22	5.3	5	52	1.87	1.05
21		17.0	5	34	1.93	1.16
29		28.8	5	8	2.00	1.29
Nov. 6	22	40.6	—4	34	2.07	1.43

COMET 1941 *f* (NEUJMIN). Word has just been received that another faint comet has been discovered not far from the region of the sky occupied by 1941 *e*. The telegraphic information dated September 9 was as follows:

Comet Neujmin magnitude 13
1941 Aug. 29 at $22^h\,29^m.2$ U.T.
Right ascension $21^h\,54^m.5$
Declination —11° 16′
Daily motion $-0^m\,28^s$ +0° 1′

These data came from the observatory at Simeis (Crimea) where Neujmin, who has already several cometary discoveries to his credit, has been active for many

years on photographic observations of asteroids. The object has further been recorded on a Harvard plate giving the later position:

1941 Sept. 9 at $1^h\,42^m.8$
Right ascension $21^h\,49^m\,52^s.2$
Declination $-11°\,30'\,40''$

which indicates that the comet moves slowly southwestward. Seen in the 40-inch telescope on September 11, it appeared as a round diffuse coma with little central condensation and the magnitude was estimated as 12. It is too early to predict the future course of this object.

Many observations have been published on COMET 1941 *d* which is now near conjunction with the sun but so far north that it can be seen both after sunset and before sunrise in the constellation of Ursa Minor. The continuation of the ephemeris by Bobone is as follows:

EPHEMERIS OF COMET 1941 *d* (VAN GENT)

1941	α h m	δ ° ′	Distance from Sun	Distance from Earth
Oct. 1	11 25.3	+45 2	1.01	1.30
5	16.1	23	1.05	1.27
9	11 6.1	+45 43	1.09	1.23
13	10 55.3	+46 3	1.13	1.19
17	43.2	23	1.17	1.14
21	29.5	46 43	1.22	1.09
25	10 13.8	47 2	1.27	1.04
29	9 55.7	18	1.32	0.99
Nov. 2	34.7	27	1.37	0.94
6	9 10.3	47 23	1.42	0.90
10	8 42.4	46 59	1.47	0.85
14	8 11.3	+46 5	1.52	0.82

The brightness did not continue to increase as was anticipated last summer. For several weeks in August the brightness remained near 7^M so that it could be easily seen in a small telescope. In October the increasing distance from the sun will reduce the brightness but the change will be slow while the distance from the earth is decreasing at first.

Another object that is again under observation is COMET 1925 II (SCHWASSMANN-WACHMANN) but it remains mostly faint. The following ephemeris by Behrens will help in locating this comet, whose striking variations of brightness in the past make it an object worth watching.

EPHEMERIS (1950.0)

	h m	° ′
Oct. 5	21 40.4	−12 7
21	38.9	12 5
Nov. 6	40.4	11 48
22	44.9	11 19
Dec. 8	21 51.7	−10 36

The correction of the ephemeris was $+2^m.0$, $+25'$ on August 23, and probably changes very slowly.

Williams Bay, Wisconsin, September 12, 1941.

Notes from Amateurs

An Unusual Aurora

Early in the evening of September 18 the writer was driving northward and before the twilight had vanished he saw indications of an auroral display. He expressed surprise at its being visible in so light a sky. A friend remarked that the aurora had been quite brilliant the night before. We watched it at intervals during the night until 2:30, when it was still very conspicuous, the flashes moving rapidly across the sky up to and sometimes beyond the zenith.

That the display was quite general is indicated by the following reports.

Northfield, Minnesota. C. H. GINGRICH.

ROCHESTER, N. Y.

On the evening of September 18 there was an unusual display of the aurora in this city. I first saw it about 8:30 P.M. At that time a very bright arch perhaps 2° wide extended clear across the sky from the eastern horizon to a point somewhat south of the zenith and to the western horizon. The exteme eastern and western portions of the arch curved slightly toward the north. A decidedly yellow coloring was quite evident. To the south of this arch and more or less parallel to it were two similar arches although considerably less brilliant. Below the arches in the southern sky were some sheets and a few faint vertical streamers, while above the southern horizon there was a fairly bright glow extending from the southeast over to the southwest. The arches very slowly drifted to the south losing their identity in the course of about 20 minutes. During all this period there was practically no display in the northern sky excepting occasionally a faint streamer running down to the horizon. The succeeding pattern consisted of growing streamers which appeared to come to a definite focus in a small area almost in the zenith. These streamers gradually spread until they seemed to cover nearly the entire sky, still coming to a focus at this point near the zenith. Now the sky was so bright that I noted a definite illumination of my surroundings from these lights. After a while the focal area in the zenith took on a strange form. There was a black central region perhaps 4° in diameter and around it a quite brilliant glow somewhat butterfly-shaped and more or less constantly flashing. It probably extended somewhat over 15° and changed form quite rapidly. The general focal area seemed quite persistent. During the next half hour the display slowly faded from the south and grew brighter in the northern sky. The streamers were replaced by very rapidly flashing sheets and curtains and the color became more decidedly green. About midnight the phenomenon seemed to be over, although there remained what seemed to be a general glow over the entire sky. The following evening there was a minor display near the northern horizon showing some broad streamers above it.

The University of Rochester, College of Arts and Science.

FLOYD C. FAIRBANKS.

ALTA, IOWA

The wide-spread displays of the northern lights on nights of September 17 and 18 were observed here under clear skies, but the exact time of beginning and ending of the displays could not be noted as the writer was otherwise engaged. The aurora of the 17th was first noticed about 9:30 P.M., but did not show much activity until about midnight and from then until about 3:30 A.M. rays were ob-

served at intervals; these were reported to me by our city night watchman the following day.

The display of 18th began to be noticeable shortly after the sun had set and it was sufficiently dark to notice it. About 8:30 P.M. over one-half the visible sky was covered with a light so bright that it was not very difficult to read coarse print and even read a watch and this brightness continued more or less until after 11:00 P.M. At times the north sky would be clear showing all stars easily, the arc having ascended to near the zenith, but nearly all the time the sky to the south was dark and stars nearly hidden. The greatest activity was noted between 9:30 and 10:30 P.M. and changes were so rapid that it was difficult to note them all,—parallel beams S.E. to N.E. near zenith, bright green rays in W., N., and E., and finally converging about 9:40 in all directions to form a corona. This continued about 10 minutes and was followed by quickly moving flames a little south of the zenith. The entire display gradually subsided and by 11:00 P.M. was quiescent, but diffuse glow continued for some hours.

The great display coincided with an extensive sunspot group which was in the vicinity of the sun's central meridian and not far from the center of the visible disc,—a favorable condition for the electrons to bombard the earth at this time of near antumnal equinox.

Astronomical and Meteorological Observatory, Alta, Iowa.

DAVID HADDEN.

CHAMPAIGN, ILL.

On September 18. 1941, I noticed a bright band in the sky extending from east to west about 40° wide in the center and tapering down to the west. The south edge was directly overhead at 8:15 C.S.T. This was the first time I noticed this light band, however others said it was seen almost immediately after the sky became dark. The sky was very dark to the north and south of this band. A bluish white light lit up the sky as if a full moon were shining. My first impression was that I was witnessing a display of Zodiacal Light as it is present at this time of year. Stars fainter than second and third magnitude were hardly visible through this haze. The light appeared brighter at the eastern and western portions of the band, probably due to the fact that we were looking at an angle where more of it could be seen than directly overhead where we looked right through the band.

At 8:30 C.S.T. the light seemed to bisect Andromeda, Cassiopeia, Draco, and a part of Boötes. At 9:00 P.M. C.S.T. the light appeared to have moved southward a few degrees. The band was wider in the east than in the west. In the east the band was broken into four distinct pulsating rays (pulsating very slowly). At 9:15 C.S.T. the main body of light had moved 8° to 10° south of its position at nine o'clock. The faint edge of the band now reached as far south as Aquila. At this time I first noticed large rays overhead running from west to east of southeast. At 9:25 C.S.T. the light in the east now resembled sheets of rain falling from an invisible cloud blown by high and fast winds. The rays were becoming smaller and more distinct lasting but a few seconds each. They seemed to be tangent to the main body of light. At 9:30 the rays were very distinct overhead and seemed to point toward a spot about 10° south of the zenith. At 9:32 the sky was filled from the far north to south of Sagittarius in the east and west with bands of light, bright curtains forming and disappearing after only a moment's time. At the end of these rays, ripples formed headed toward the converging point. About 2 or 3 ripples a second was the average. Lights to the

south were quite similar to sheet lightning. At 9:42 the light faded out all over the sky only to come back twice as bright. Rays lit up the northern half of the sky while the southern half was lit by sheets that traveled north until they reached the converging point.

At 10:10 still curtains were seen in all northern portions of sky. At 10:15 the main body of light had disappeared, supplemented only by curtains in the sky. At 10:30 most of the sky was clear. My observations were over by 11:35 when there was no more trace of display.

Other displays beginning again at 12:00 o'clock continued throughout the night.

121 W. University, Champaign, Ill. CHAS. TAPSCOTT.

Junior Astronomy Club of the Hayden Planetarium

The Junior Astronomy Club is carrying on its usual program of summer observations including a spirited point contest among its members. Through the courtesy of New York's Park Department, observations are made weekly from one of the city's public golf courses.

The schedule of Club meetings for the fall of 1941 is given below. Meetings are held on Saturday evenings at 8:00 p.m., in the American Museum of Natural History, Central Park West at 79th Street, New York City. Free tickets are available on request.

Oct. 11—Eclipses I Have Seen—Dr. Clyde Fisher, Honorary Curator Hayden Planetarium.

Oct. 25—Time—Lawrence Kleiger, President, Junior Astronomy Club.

Nov. 8—Amateur Astronomical Photography—Albert R. Luechinger, Pres. Long Island Astronomical Society.

Nov. 22—Energy from the Sun—James B. Rothschild, Adviser, Jr. Ast. Club.

Dec. 6—Variable Stars—Dr. Luigi Lacchia, Harvard College Observatory.

JAMES B. ROTHSCHILD, *Adviser, Jr. Astr. Club.*

Optical Reversal of Relief on the Moon

Some months ago I secured some 8x10 prints of the Moon, showing certain areas in considerable detail. One of these prints showed the area rich in craters and while making a careful study of the photograph I was surprised to find that all the craters seemed to protrude above the surface and this illusion persisted in spite of efforts to correct it, until the print was turned to a sharp angle to the line of vision. Then the illusion would come and go but independent of any effort on my part. I might view the print for several minutes at a time and under a reading glass of moderate power also, yet the picture would appear in its proper relief and then perhaps it would snap into sudden reversal.

My eyes seemed to be in normal condition and without fatigue or strain.

Years ago with a small spyglass, magnifying about 25 times and using a double concave eyepiece, I sometimes got the same effect, some of the craters standing out like drops of water on polished silver. I did not then get the reversal with a convex eyepiece. However, recently with a power of 100X and 150X I got the reversal which was rather persistent but was not noticed with lower or higher powers. Stopping down the objective was not tried. This illusion persists in spite of one's better judgment when it does occur, which is not often.

I suppose other observers have experienced this illusion either at the eyepiece or with photographs but I have seen no mention of it in the rather extensive reading I have done.

W. E. DUCKWALL.

Hillsboro, Ohio.

General Notes

Because of an unexpected change of plans the information contained in the first "General Note" in the August issue is not valid. The editor, who was to have a leave of absence during the first semester of this year, found it necessary to remain in residence throughout the year. The work and the responsibility of this magazine will therefore remain as in former years.

Dr. Dean B. McLaughlin and **Dr. Will Carl Rufus,** both of the department of astronomy at the University of Michigan, have been promoted to the rank of professor.

Dr. Richard S. Zug, for five years a member of the department of Astronomy in Carleton College, accepted a civil service appointment and is now engaged in computations related to the work in ballistics which is in progress at the proving ground at Aberdeen, Maryland.

Dr. Clyde Fisher, curator-in-chief of astronomy and director of the Hayden Planetarium of the American Museum of Natural History, who has been a member of the scientific staff for twenty-eight years, retired on August 1 and will become honorary curator of astronomy and honorary director of the planetarium. He will be succeeded by William H. Barton, Jr., who has been executive curator of the planetarium. (*Science,* August 8, 1941)

Junior Meteorologist Examination Announced by Civil Service Commission

Again the pressing needs of the National Defense Program have caused the Civil Service Commission to announce an examination for Junior Meteorologist positions paying $2,000 a year. There were not enough eligibles obtained as a result of the written test given under the Junior Professional Assistant examination early this year. Accordingly, applications for the new examination will be accepted until June 30, 1942, and the new meteorologist examination will be of the unassembled type—that is, no written test will be given. Applications will be rated as soon as possible after they are received at the Commission's Washington office, and those rated eligible will have their names placed on the register set up as a result of the written examination given for the Junior Meteorologist option of the 1941 Junior Professional Assistant examination.

Junior meteorologists will in general apply air-mass analysis and related procedures to the charting and interpreting of weather data. This will include the preparation of weather forecasts, the conducting of investigations in synoptic meteorology and of climatic, physical, and dynamic phenomena of the atmosphere. They may also conduct investigations of the relation between intensity and areal distribution of precipitation and subsequent streamflow.

To qualify for these position applicants must have completed a 4-year college course which included courses in differential and integral calculus, 12 semester hours in physics and 6 semester hours in meteorology. For this last course requirement, however, applicants may substitute 1 year of professional experience in meteorological work corresponding to the duties outlined above.

In the rating procedure additional credit will be given for graduate study in

meteorology and for professional experience in that field although neither is required. Provision is made for the acceptance of applications from senior or graduate students although they may not be certified for appointment before they have completed the required course work.

For some time the Commission has been accepting applications for meteorologist positions paying from $2,600 to $5,600 a year (Announcement No. 61 of 1941). Separate employment lists are being established in each grade for every branch of meteorology. For these positions completion of appropriate college study and experience are required.

Further information and application forms may be obtained at any first- or second-class post office or from the Civil Service Commission at Washington. Applications for all the meteorologist positions should be sent to the Commission's central office in Washington, D. C.

Book Reviews

The Universe Surveyed, by Harold Richards. (D. Van Nostrand Company, Inc., 250 Fourth Ave., New York. $3.50.)

This volume, though published in 1937, has only recently come to our notice. We are so favorably impressed with the commendable qualities of this book that even at this late date we wish to call it to the attention of our readers.

The survey covers the basic natural sciences of Physics, Chemistry, Astronomy, and Geology. The discussion is not made of each of these separately but all are interwoven in the discussion as a whole thus showing that actually *a universe* is being surveyed rather than several universes. The volume is abstract in places and quite concrete in others. Theories are discussed and practical applications are described. The author's grasp of the fields he is dealing with is thorough, and his style of writing is captivating.

The volume consists of 722 pages. It is divided into four units and eighteen chapters. The concluding pages are given to an *Astronomical Supplement* and to an *Appendix* which consists of a list of 850 questions phrased as a true-false test would be. It also contains tables of the chemical elements and a complete index.

The quality of the paper used, the style of printing, and the binding are of the best, and hence in keeping with the reviewer's impression of the contents. All in all it is a volume worthy of being recommended to librarians and students alike. C.H.G.

Astronomy, by Clyde Fisher and Marian Lockwood. (John Wiley and Sons, Inc., New York. $2.25.)

This volume, published in 1940, is one of a series of texts for a survey course in the sciences for colleges. Other volumes already published in this series pertain to Physics, Chemistry, Earth Sciences, Biology, and the Body Functions. The series is under the editorship of Dr. Gerald Wendt.

The volume before us consists of ten chapters, a bibliography, a glossary, and an index, covering 205 pages. The usual topics essential to a first or survey course in astronomy are treated. Starting with the Earth, the reader is advanced with ever increasing distances to the Moon, Sun, Planets, Comets, Stars, Galaxies. There is a chapter on Astronomical Instruments, one on Variable Stars, Double

Stars, and Clusters, and one on the Constellations. It, therefore, very nicely serves the purpose of a survey text. It contains numerous photographs of astronomical objects very well reproduced. Brief lists of titles at the ends of the several chapters suggest abundant material for those who wish to pursue a particular topic further.

The volume is so arranged as to serve as a textbook in a first general course, or as a source of information relating to basic astronomical facts for the general reader. C.H.G.

Handbook of Chemistry (Fourth Edition), by Norbert Adolph Lange. (Handbook Publishers, Inc., Sandusky, Ohio. $6.00.)

The fourth edition of this Handbook bears the date of 1941. It contains 85 pages of new material not included in the Third Edition, published two years earlier. Numerous changes in former tables have been made in order to bring them up-to-date, and eleven new tables have been introduced. The total number of pages in this edition is 1985.

The amount of information here available for the theoretical scientist as well as for the practical engineer is stupendous. It would, indeed, be difficult to think of any scientific data which are not included. Such a comprehensive statement shows the utter impracticability of an attempt to list the contents.

The volume is of gilt edged pages handsomely and durably bound in blue, flexible fabricoid, the color thus easily differentiating it from the third edition which is green.

In a word, since scientific facts have become so numerous and so interrelated, no one can be expected to carry more than a small fraction of them in his memory. The necessity for having a compilation such as this in every laboratory and every library is clearly indicated. It would seem that, because of its scope and detail, the volume before us is the final word in handbook making to date. C.H.G.

The Defense of Galileo of Thomas Campanella. A translation of the above-named paper appeared in *Smith College Studies in History,* Volume XXII, Nos. 3-4. The translation was made by Dr. Grant McColley who states that it is the first time the paper has been translated into English. It is accompanied by an introduction and extensive notes.

This contributes one more item to the English literature bearing upon this frequently mentioned incident in the history of science. The present discussion is concerned chiefly with reconciling the views of Galileo with statements in the scriptures. The maker of the defense does not attempt to contradict or nullify the scriptural statements but points to possible different interpretations. This attitude on his part is indicated in his closing paragraph, "In the above statements, discussions, and writings I at all times submit myself to the correction and better judgment of our Holy Mother, the Roman Church."

With the large amount of material related to the this question now available, the facts by this time should be quite clear. C.H.G.

Publications of the Astronomical Observatory, University of Minnesota, Volume II, Number 11.

This pamphlet consists of pages 229 to 237, inclusive, of Volume II. It is a continuation of Dr. Luyten's Bruce Proper Motion Survey. This part is entitled, "A Preliminary Statistical Discussion of White Dwarfs."